Greening The X

A Vision for Green Streets in Springfield, MA

Eric DePalo Breyonne Golding - The Conway School Winter 2016


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Contents

Acknowledgments

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Executive Summary

Springfield, Massachusetts is a historic city with an incredible legacy of inventions and innovations, one of the first industrial cities in the world. Like more than 100 other post-industrial communities in New England, Springfield has a combined sewer and stormwater system (CSS).

In a CSS, stormwater runoff and sanitary sewers use the same underground infrastructure to convey effluent to the wastewater treatment plant. Under dry conditions and during an average rain, these systems are adequate. Unfortunately, during a heavy rain event the CSS is overwhelmed by the volume of stormwater runoff draining from the streets and the system discharges raw sewage into the Connecticut River in a Combined Sewer Overflow (CSO) event. This phenomenon will only become more problematic as climate change makes storms larger and wetter.

Motivated by concern for public health and the local ecosystem — and also mandated by the Environmental Protection Agency — the Department of Public Works, in tandem with the Pioneer Valley Planning Commission and the U.S. Forest Service, has asked the Conway School to create a vision for Green Streets at the X intersection in the Forest Park neighborhood of Springfield. These Green Streets give stormwater runoff a chance to infiltrate into the soil, removing it from the CSS and reducing the likelihood of an overflow event. Green Street components not only make the city more beautiful but are associated with better mental and physical health of nearby residents and are less costly over the life-span of the system.

The Conway School held two public meetings to understand how residents currently use the X intersection and what needs a new design could address. This feedback was integrated with regional, city and site analysis to apply a toolbox of Green Street components to the new "Complete Streets" proposal for the intersection. This book is intended to inform and inspire city workers and community members alike about the benefits of Green Streets and how they might apply to the X neighborhood and beyond.

Many cities around the country are becoming aware of the benefits of Green Streets and are beginning to implement these systems across the urban landscape. It is the hope of this project that, armed with the right information, Springfield will join the Green Streets movement, adopt these systems, reap the benefits and continue its legacy as a city of innovation.

INTRODUCTION

Main Street at the beginning of the 20th century was built for people and public transportation - not an automobile in sight!

Springfield has been an eventful and innovative crossroads of human activity for centuries.

Four hundred years ago, the land underneath the City of Springfield sat at the intersection of two well-used thoroughfares, one road traversing east-west from Boston to Albany and the other traversing north-south from Montreal to New York City. This is why in 1636, William Pynchon chose the site to establish a colony with an economy based successfully on both trade and agriculture. The strategic location is also why, 140 years later, George Washington sited the nation's first armory on the high bluffs overlooking the Connecticut River. This event would profoundly shape the future of the city.

The armory became the seed of an unprecedented expansion of industrial capacity nicknamed today, "the silicon valley of the industrial revolution." In the 19th century, the city boasted that it was the "City of Progress" and, after establishing an impressive list of inventions and innovation, adopted the moniker "the City of Firsts." By the 20th century the city picked yet two more nicknames: the "City of Homes," for its large, prosperous, home-owning middle class and the "City in a Forest," an homage to its picturesque urban landscape, braided with parks and trees. One 1910 resident noted that, "Springfield has the most attractive streets in New England." With centuries of wealth invested into city infrastructure, Springfield was one of the most prosperous cities of its size in the nation.

Starting in the middle of the 20th century a number of changes radically reshaped the urban landscape. In 1958, construction began on Interstate 91, an elevated highway that isolated Springfield from the Connecticut River physically, visually and psychologically. In 1968 the Springfield armory closed, a bellwether of shifting economies and demographics across the industrial landscape of New England. The city began to suffer from high crime, urban blight and shrinking municipal budgets that could no longer maintain infrastructure built in a time of prosperity.

Car-oriented development on the eastern fringe of the city began to consume the remaining woodland and agricultural fields in the 1970s as tens of thousands of residents pursued the suburban dream, evacuating the center of the city, leaving many industrial buildings and "Painted Lady" Victorians empty. This image of a failed city, despite being so diametrical to its long and impressive history, is how many people think of Springfield today.

This image, however, has begun to change. Many successful initiatives have encouraged the city to retrofit urban infrastructure to better serve the community, such as the recent "Complete Streets" initiative. This plan proposes to retrofit city streets to accommodate all people regardless of their ability or mode of transportation. Furthermore, several groups emerged in the wake of the powerful tornado of June 2011 such as ReBuild Springfield (now ReDevelop Springfield) and ReGreen Springfield, the latter of which has helped to secure funds for this project.

This project presents an opportunity to rehabilitate old infrastructure in cost effective ways while repairing the city's relationship to the Connecticut River. The X neighborhood serves as a case study to demonstrate ecological stormwater treatment systems that might inspire action across the city.

Within the crossroads of Springfield sits another crossroads, the intersection of Sumner Avenue, Belmont Avenue and Dickinson Street.

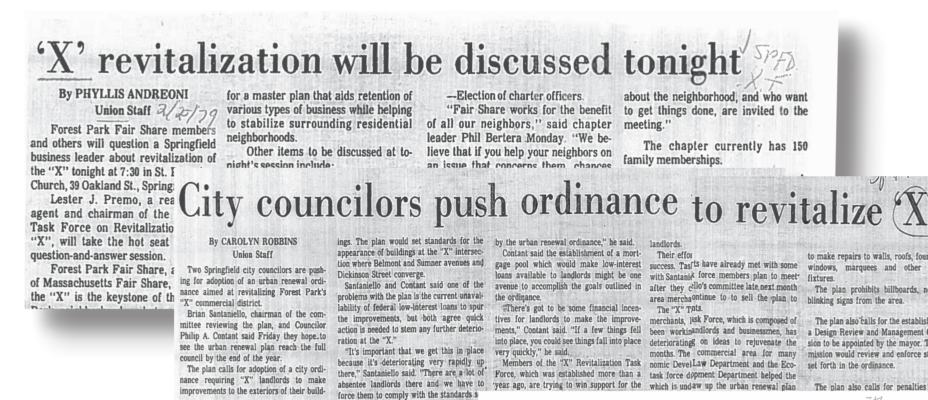
Dating back to the mid 18th century, the X intersection sits within the Forest Park neighborhood, established concurrently with Forest Park in 1884. Sewers first came to the area in the 1880s, followed shortly by electric and streetcar lines and finally a localized housing boom that would populate the neighborhood with hundreds of elaborate Victorian and Tudor mansions by 1920.

As carriages and streetcars gave way to the automobile, the X became a congested commercial hub replete with an array of locally-owned drug stores, bakeries, diners, cleaners, food markets and department stores. In the 1950s-1960s, the X was the city's largest shopping district outside downtown Springfield and, as one neighborhood resident claimed, "the perfect place to grow up." By the late 1970s, however, the neighborhood began to suffer in proportion to the struggling city. The X became more known as a place to drive through than a place to stop and linger.

Although the modern X is known for its Vietnamese restaurants, barber, pub, and assortment of franchise stores, it is also known as one of the most dangerous intersections to drive or walk in Springfield (OSRAP 51). In order to improve safety and the flow of traffic through the intersection, the city has recently announced an ambitious "Complete Streets" renovations which include roundabouts and pedestrian plazas.

Though "complete" in terms of human circulation, these plans are missing a consideration of ecology at the X. By dovetailing the "Complete Street" renovations proposed for the intersection with the "Green Streets" designs presented in this book, the X can again become the safe, vibrant, beautiful space that it was a century ago.

Numerous fliers and articles dating from the 1970's attest to the desire of the community to make the X safer, economically vibrant and beautiful.



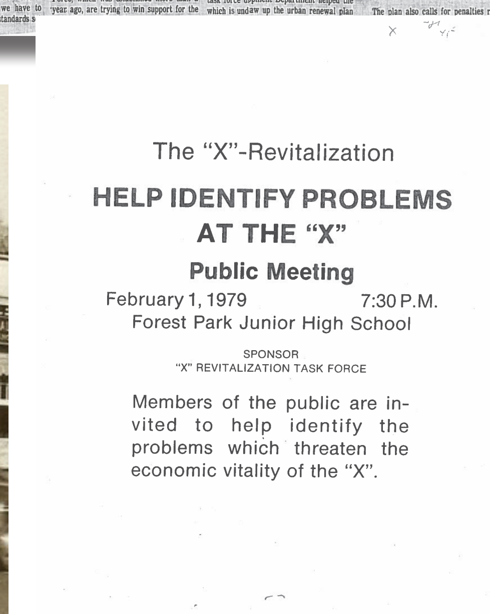
'X' revitalization will be discussed tonight

By PHYLLIS ANDREONI
Union Staff

City councilors push ordinance to revitalize 'X'

By CAROLYN ROBBINS
Union Staff

Cop in a Box - Necessary for pedestrian safety in the 1950s



The "X"-Revitalization

HELP IDENTIFY PROBLEMS AT THE "X"

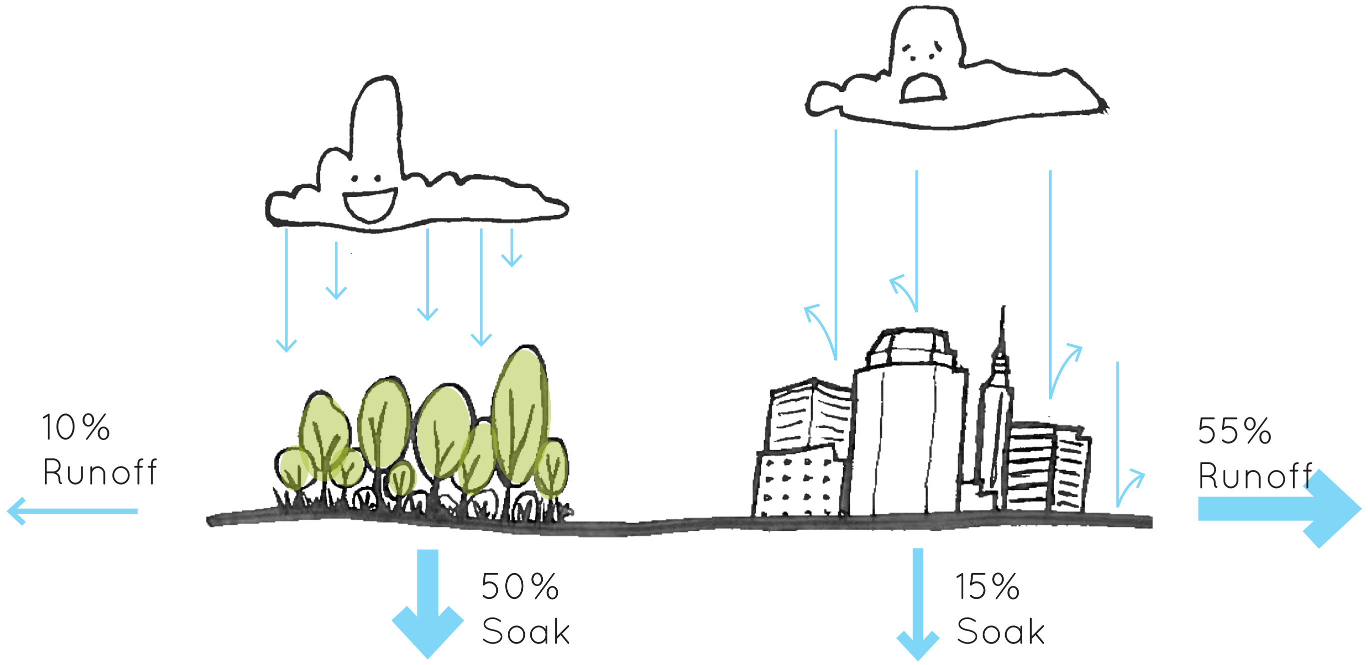
Public Meeting

February 1, 1979 7:30 P.M.
Forest Park Junior High School

SPONSOR
"X" REVITALIZATION TASK FORCE

Members of the public are invited to help identify the problems which threaten the economic vitality of the "X".

Needs Assessment



In a natural setting such as Forest Park, pictured on the left in the illustration above, water falls as rain onto the landscape and replenishes the groundwater.

In a city like Springfield, pictured on the right, rain is not able to infiltrate into the ground.

In Forest Park, water infiltrates the surface of the earth and is stored in the soil. This water is either returned back into the air by the action of tree roots and leaves or it penetrates deeper into the ground, recharging subterranean aquifers. Water is cleaned through this cycle of infiltration into the soil and transpiration through the living tissue of plants.

In contrast, in an urban setting, rain sheets off roofs, sidewalks, parking lots, and roads and runs off into stormwater drains. Only a small percentage of this water is able to be cleaned by cycling through the soil ecosystem.

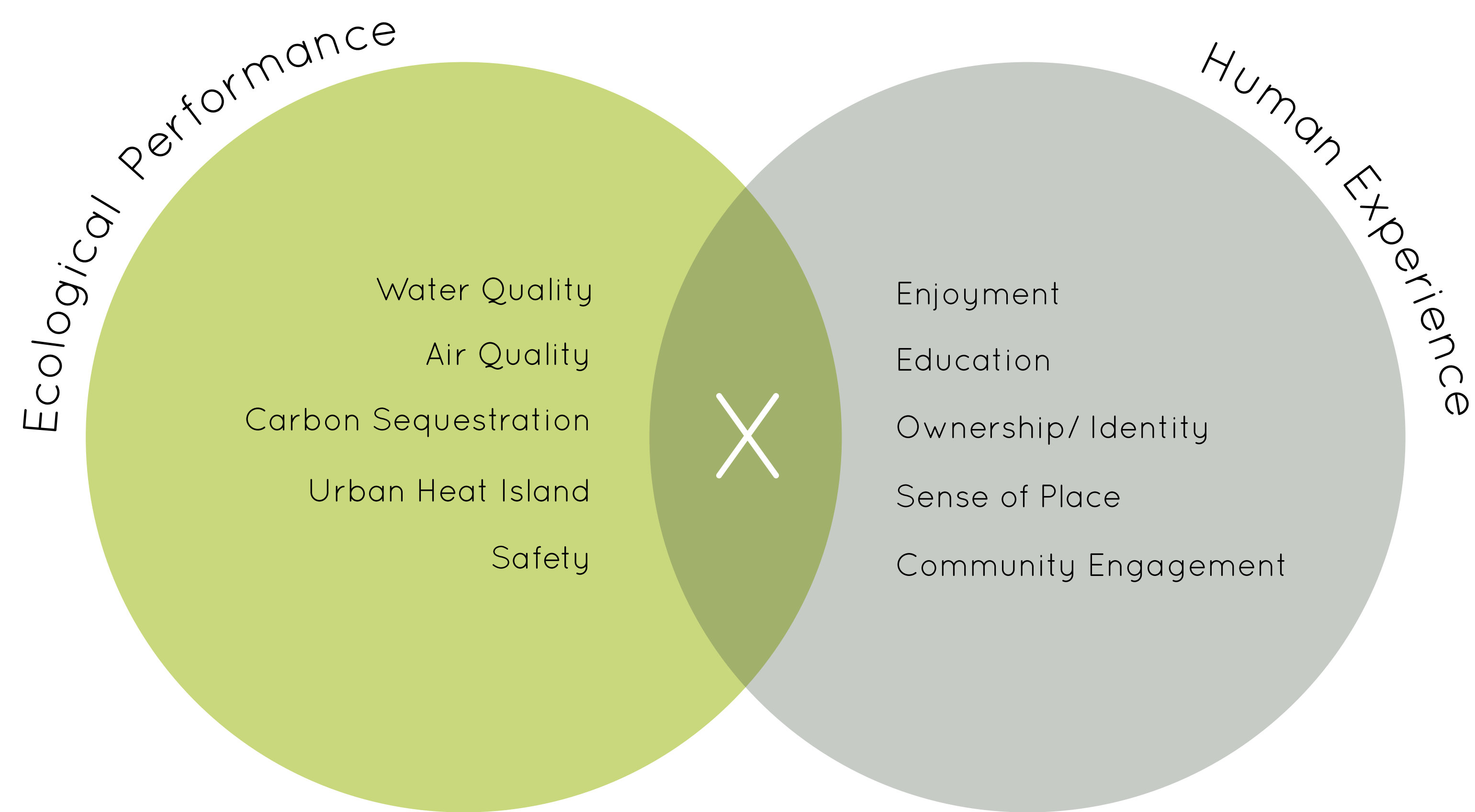
Water in the street also picks up numerous toxins, including pesticides and herbicides, heavy metals, bacteria, and salts. These substances are carcinogenic and suppress the immune system; they are detrimental to the human body, plants and animals.

Springfield, like 100 other communities in New England, has a Combined Sewer System (Fact sheet 2). This means that stormwater and septic sewage drain through the same pipes. Under dry conditions and during a light rain, these systems are adequate and water is directed to the wastewater treatment plant. In a heavy rain, however, this combined sewer system is overwhelmed by the volume of water and, in order to prevent basements and streets from backing up with sewage, untreated effluent overflows into the Connecticut River.

According to the Massachusetts Department of Environmental Protection, Chicopee, Holyoke, Springfield, Ludlow, South Hadley and West Springfield collectively discharge 1.8 billion gallons of raw sewage into the river annually. These events will become only more likely as climate change increases the likelihood of extreme rain events in New England.

These Combined Sewer Overflow (CSO) events are costly to public health. According to one Environmental Protection Agency estimate, up to 3.5 million people become sick from contact with water contaminated by sewage every year (Banking on Green 29). Contact with this water can cause gastroenteritis, eye, ear and respiratory infections, skin rashes, hepatitis and other diseases (Fact sheet 1). CSOs limit recreational activities such as fishing, swimming and even boating on the river.

Overflow events are also costly financially. Cities across the country are facing a total of $106 billion dollars worth of CSO abatement projects. Since 2004 Springfield has spent $62 million in CSO abatement projects, and estimates the need to spend $160 million more to eliminate discharge events. (OSRAP 32)



How can we retrofit the streets of the X neighborhood to provide ecological performance as well as a positive human experience?

"Development of cost effective projects to control combined sewer overflow has become a public works crisis nationally. The USEPA has mandated CSO communities commit to controlling these overflows without providing meaningful financial aid to fund these projects."

Springfield Open Space and Recover Action Plan, Page 32

In order to find cost effective techniques to improve water quality and abide by USEPA mandate, the Pioneer Valley Planning Commission (PVPC) and the City of Springfield Department of Public Works in tandem with the National Park Service contacted the Conway School to help design ecological stormwater infrastructure for the X neighborhood — a technique often called "Green Streets."

A Green Street reduces impermeable surface area in the street and allows water to infiltrate on site. By slowing water down and reducing the peak flow of a rain event, a street that has been "greened" reduces the likelihood of a CSO event in the city.

Behaving more like a forest than a parking lot, green streets also yield countless ancillary benefits to the city, both improving ecological performance and the livability of a city. This book explores how these systems might apply to the landscape of Springfield and the X neighborhood.

What is a Green Street?

***Green Streets*, *Green Infrastructure (GI)*, *Low Impact Development (LID)*... as "green" technologies have become increasingly popular in this age of climate change, terminology has proliferated.**

Whatever the name, the technique remains the same: slow water down and give it time to percolate into the soil. As the water passes through the biological activity of the soil, toxins are broken down and rainwater recharges the water table instead of rushing off to cause erosion and pollution downstream.

In essence, "Green Streets" are a strategy to make our urban infrastructure behave more like a natural ecosystem, with a host of associated benefits to all residents, human and otherwise. Most of these benefits, noted in the chart on the opposite page, do not occur with gray infrastructure. Furthermore, green technologies are increasingly more cost effective than their gray counterparts.

Philadelphia, for example, a leader in the application of green infrastructure to urban environments, has committed two billion dollars to green streets over the next two decades. Despite the high capital cost, the city projects the new infrastructure to generate more value than costs to the city within 45 years. Through an in-depth comparison between green and grey infrastructure, the Philadelphia Water Department demonstrated that:

> *"for equal investment amounts and similar overflow volume reductions, the use of LID/GI would provide 20 times the benefits of traditional stormwater infrastructure such as large tunnels and pumping stations. The benefits quantified and monetized as part of this analysis included increased recreational opportunities, air quality improvements, water quality and ecosystem enhancement, creation of LID/GI-based jobs, increased property values, and reduced urban heat stress." (EPA BENEFITS 39)*

Green Infrastructure installations across the country:

The **City of Lenexa, Kansas**, when implementing green infrastructure for multi-family, commercial, and warehouse developments, found significant cost savings in contrast to traditional conventional management approaches.

West Union, Iowa, found that although capital costs associated with permeable pavement were initially more expensive, life-cycle cost calculations indicated that the systems would pay for themselves by year 15. Permeable pavement will save the city $2.5 million over a 57 year period.

The **Capitol Region Watershed District in Minnesota** found a new storm sewer for conveying untreated, frequent floodwaters to Lake Como was estimated to cost $2.5 million compared to $2.0 million for implementing GI infiltration practices, as well as improving the water quality of a nearby lake.

In **Portland, Maine** the Bureau of Environmental Services calculated that their green roof systems would pay for themselves within 20 years, doubling the life span of the roof and saving owners about $400,000.

In addition, comprehensive citywide suitability analysis performed by the Portland Bureau of Environmental Services, the Los Angeles County Department of Public Works, and The Capitol Region Watershed District (CRWD) of Minnesota share similar conclusions: green infrastructure has cost-saving potential across the city.

(EPA BENEFITS 39)

THE BENEFITS OF GREEN STREETS

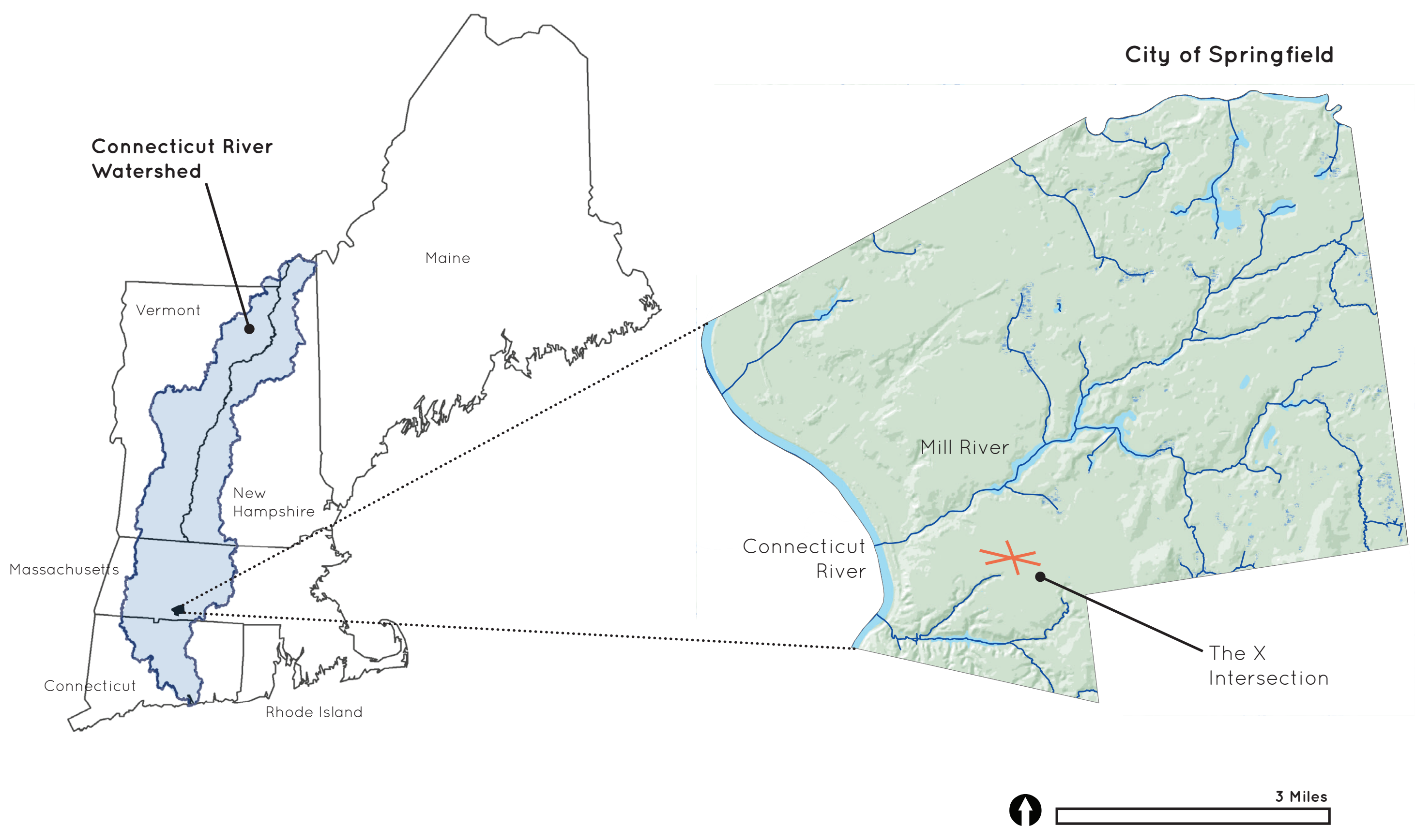
Metric	Benefit
Air Quality	Living plants reduce particulate matter in the air associated with poor respiratory health (G2G Final Report, 3.1). Reducing these ambient pollutants reduces incidents of asthma, bronchitis, lung disease and respiratory infections.
Increased "Greenness"	"Greenness" is associated with positive effects on physical and mental health. Increased access to green space is directly connected to lower levels of obesity, stress, ADHD symptoms and depression, and increased levels of physical activity, longer life expectancy, and a more positive outlook.
Energy Savings	Electricity is used to pump stormwater runoff to the wastewater treatment plant and to heat and cool buildings. A city incorporating green infrastructure uses living trees and plants to treat water as well as shade and insulate buildings, reducing demand for electricity.
Greenhouse Gases	Reduced electricity use reduces demands on burning fossil fuels, which releases carbon into the atmosphere. Additionally, trees and soils lock away carbon, also reducing the percentage present in the atmosphere.
Property Values	Increasing the attractiveness of the neighborhood increases the value of houses nearby.
Community Cohesion	Increased vegetation encourages use of outdoor spaces, neighborly interaction and thus social capital. Vegetation is also associated with reduced crime rates for reasons that are not entirely known — perhaps because it shows that a neighborhood is "well cared for."
Environmental Justice	In minority/low income areas it may be difficult or impossible to travel outside of the city to access protected forests. Green streets bring nature to people who need it most.

Adapted from Portland Green Infrastructure, pp 2-3

INVENTORY &

ANALYSES

Regional: Watershed



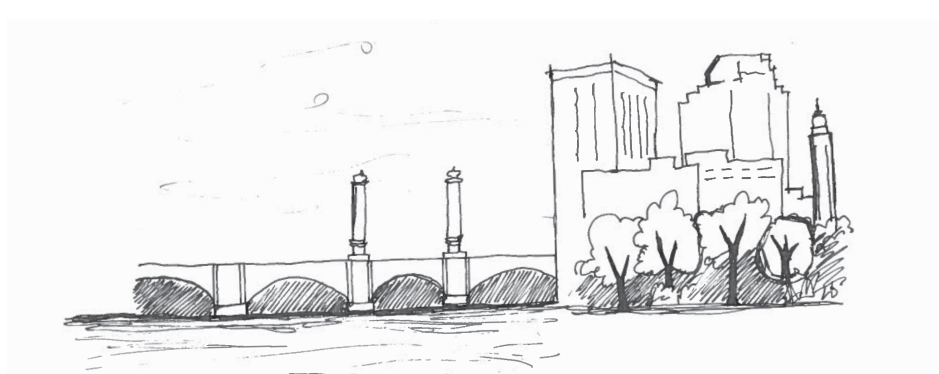
The Connecticut River is the largest river in New England, flowing from the very tip of New Hampshire to the Long Island Sound, traversing over 400 miles through four of the six New England states. In 1997, the river was designated an American Heritage River, for its distinct natural, economic, agricultural, scenic, historic, cultural and recreational qualities.

The Connecticut River watershed drains an incredible 11,200 square miles of land. **Springfield is the largest municipality within this watershed, meaning it has significant influence on the overall health of the river ecosystem.**

Within the city, water flows generally from East to West, downhill through the Mill River towards the Connecticut River.

Major flooding and property damage in the early 1900s resulted in the construction of twelve dams to regulate water flow across the city. This has led to a drier and safer city at the expense of the local ecosystems that naturally absorb, store and/or transport stormwater.

Green street techniques restore natural ecological function of the urbanized watershed, restoring in a small way the ecological integrity of the original system. By mimicking a natural ecosystem, these techniques help to infiltrate stormwater runoff on site, reducing its displacement into the river.



City Skyline over Connecticut River

Citywide: Impermeable Surfaces

Springfield's legacy of industry is manifest in the landscape, perhaps most evidently in the extremely high percentage (36%) of impermeable surfaces across the urban landscape. One out of every 3 square feet is covered in road, sidewalk, driveway or roof.

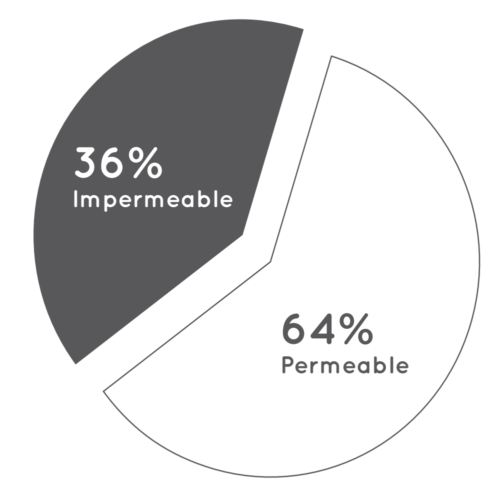
According to the Environmental Protection Agency (EPA) more than 10% impermeable cover within a watershed can damage the health of the local waterways, and over 30% is potentially irreparable.

If Springfield is to improve the ecological vitality and of its waterways the city must reduce this percentage of impermeable surface.

In Springfield there are approximately 7,815 acres of impermeable surfaces, 72% of which are streets, sidewalks and parking lots and 28% of which are roofs. Hypothetically, to decontaminate and infiltrate the volume of all the stormwater running off this sea of impermeable surface, the city would need to construct a wetland one foot deep and over 600 acres in area.

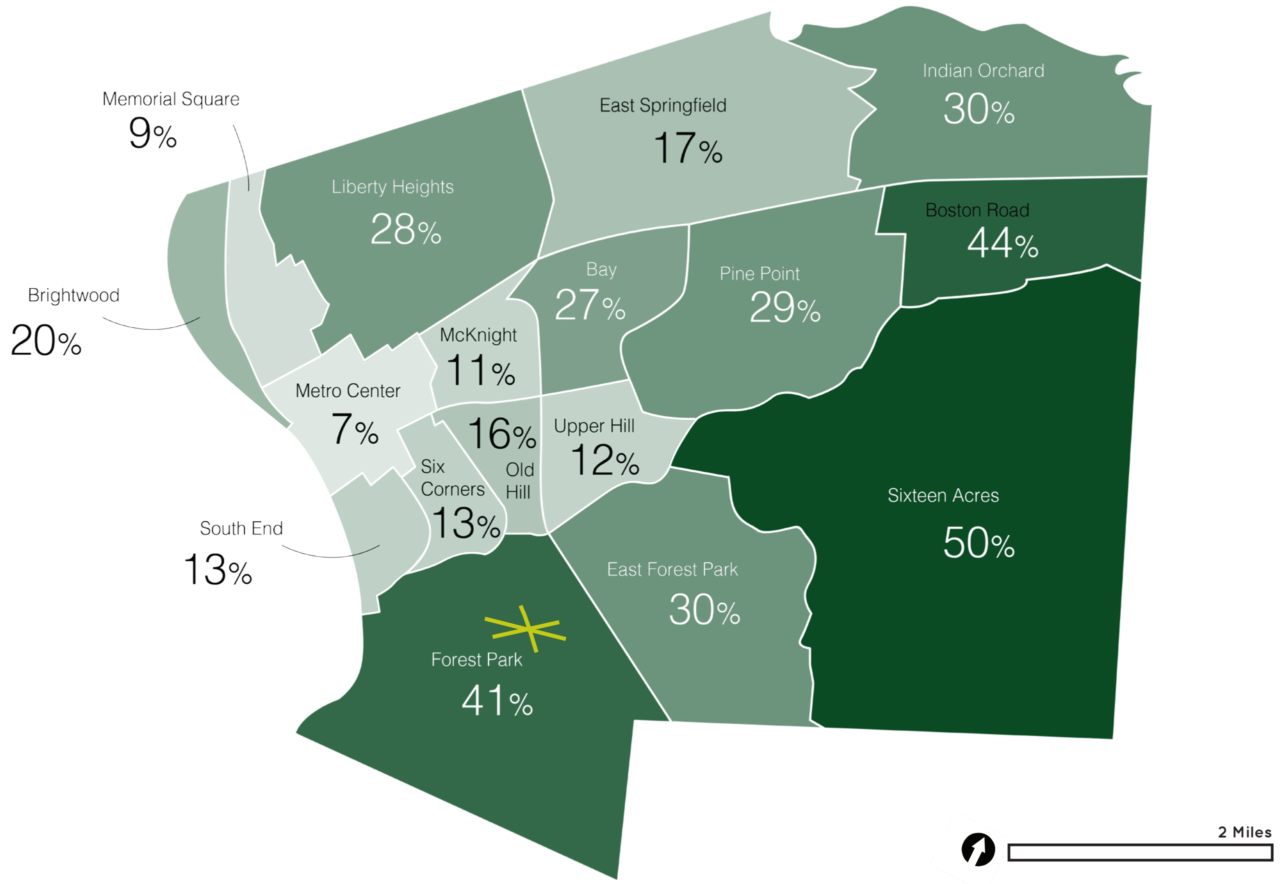
A more viable technique is to use a constellation of Green Street components across the city to break up the asphalt street and allow water to infiltrate on site. **By turning gray streets green, the city can reduce its total percentage of impermeable surfaces.**

Type of Surfaces



The City of Springfield has 36% Impermeable (water resistant) surfaces and 64% permeable surfaces.

Citywide: Tree Canopy Cover by Neighborhood



A tree intercepts rainfall with the surface area of its leaves, absorbing some and transpiring the rest. Trees also pump water directly from ground into the air in a process known as transpiration. This process helps to break down organic chemicals present in the runoff as it rehydrates the atmosphere.

Tree canopy cover is closely correlated with watershed health. At least 45% tree cover is recommended to keep the ecology of local streams and rivers intact. Not all neighborhoods in the city have equal density of tree canopy cover. Low population density neighborhoods such as Sixteen Acres have upwards of 50% tree canopy cover, while neighborhoods in the dense urban core have less than 10% tree canopy cover, the least being Metro Center with just under 7%. These areas are most susceptible to the urban heat island effect.

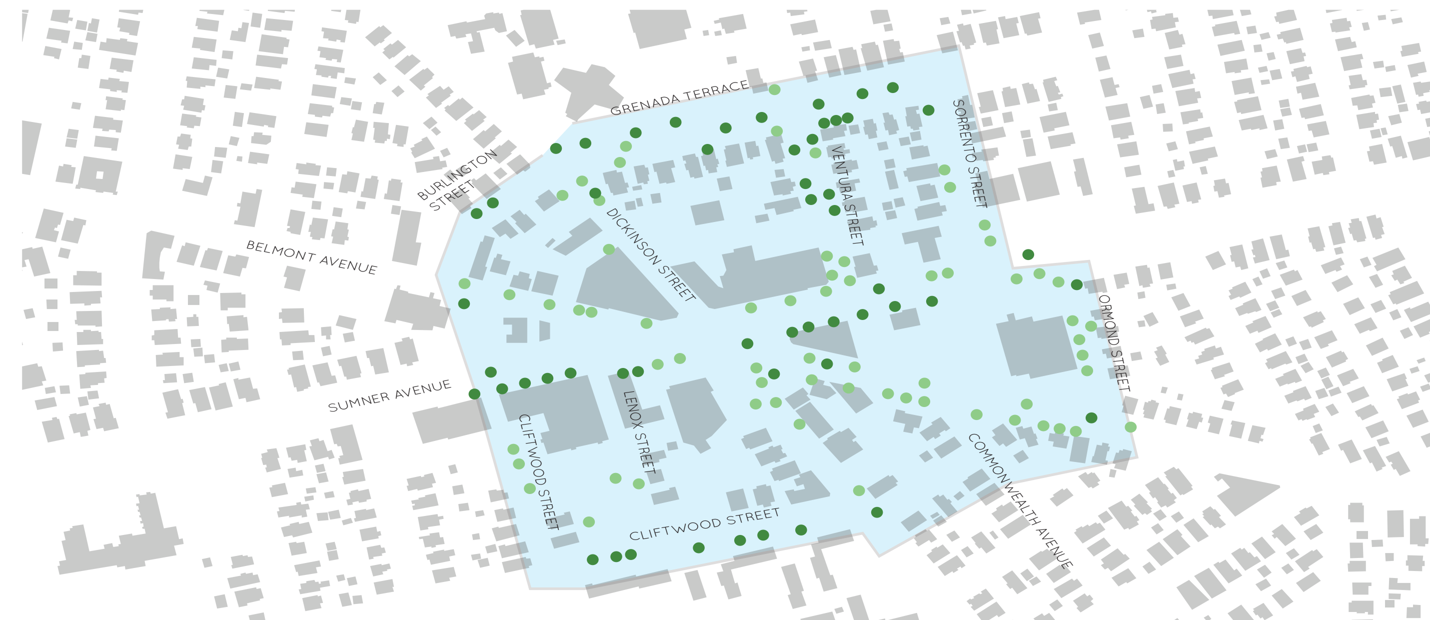
The X itself is located within the Forest Park neighborhood, which is one of the most vegetated areas in the city at 41% cover. The percentage of tree cover in the neighborhood, however, is skewed by the presence of the 735 acre urban park (Forest Park), located southwest of the X. Without this park, the overall percentage tree cover in the neighborhood would be much lower and more representative of the dense urban feel of the X.

Incorporating trees into the street infrastructure is an important strategy for increasing overall tree canopy on public land, granting access to nature to those residents who need it most.

Nature's Umbrella:

The surface area of leaves in the tree intercepts, absorbs, and slows down rainfall before hitting the ground, helping to reduce the flow of water draining toward the combined sewer system.

Site: Tree Inventory



LEGEND

Project Site Boundary

Large/ Mature Trees (56)

Small/ Young Trees (67)

1000 Feet

Springfield is home to a diverse group of trees that thrive in the urban environment. These include small tree species such as Eastern Redbud, medium-size trees like the Thornless Honeylocust and large individuals such as the London Planetree.

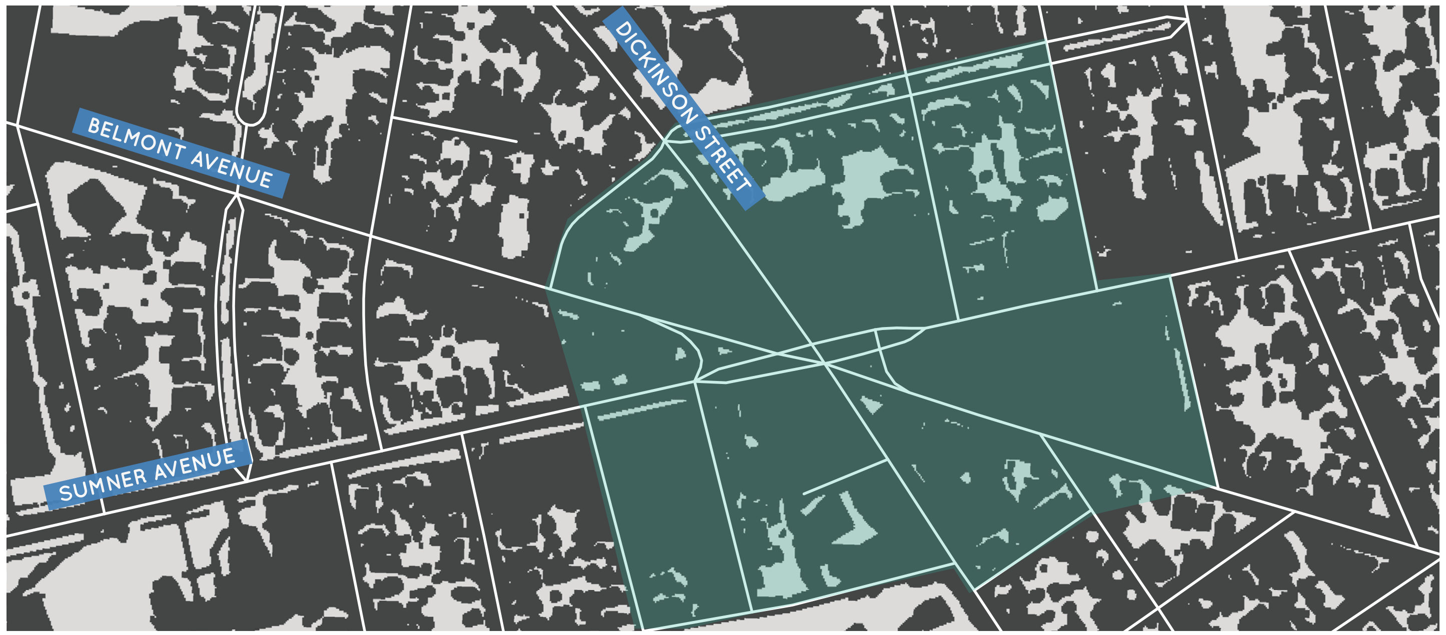
The boundaries of the X intersection are defined for this project as a twenty-nine acre polygon bounded by Burlington Street, Belmont Avenue, Sumner Avenue, Cliftwood Street, Trenton Street, Commonwealth Avenue, Ormond Street, Sorrento Street, and Grenada Terrace. Within this site trees are not distributed evenly. Sumner Avenue and Grenada Terrace have rows of tall oak and maple trees along the roadside, while streets such as Trenton and Lenox have few trees.

In these areas, street trees are an even more precious resource that the public depends upon for shade, clean air and a beautiful connection to nature.

The map above illustrates where street trees currently exist in the public right-of-way. Fifty-six trees were noted as large or mature and future designs need to accommodate these specimen. Sixty-seven trees were noted as small or young and any future design will have to weigh their value to determine if the trees should be replaced with a green infrastructure component or not.

Large gaps between existing trees in the map above are significant opportunities for future Green Street installations.

The landmark evergreen "Christmas" tree at the intersection of Belmont and Sumner.



LEGEND
- Project Site Boundary
- Impermeable Surfaces
- Permeable Surfaces

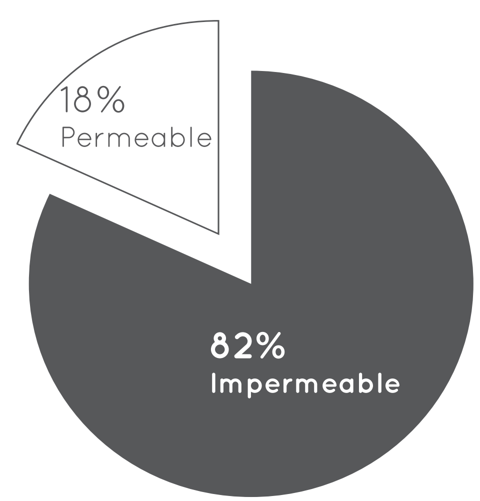
1000 Feet

Although located near a large park, the X neighborhood feels more like downtown Springfield in the Metro Center neighborhood. This is at least partly because 82% of the surface within the X is covered with asphalt or other impermeable surface.

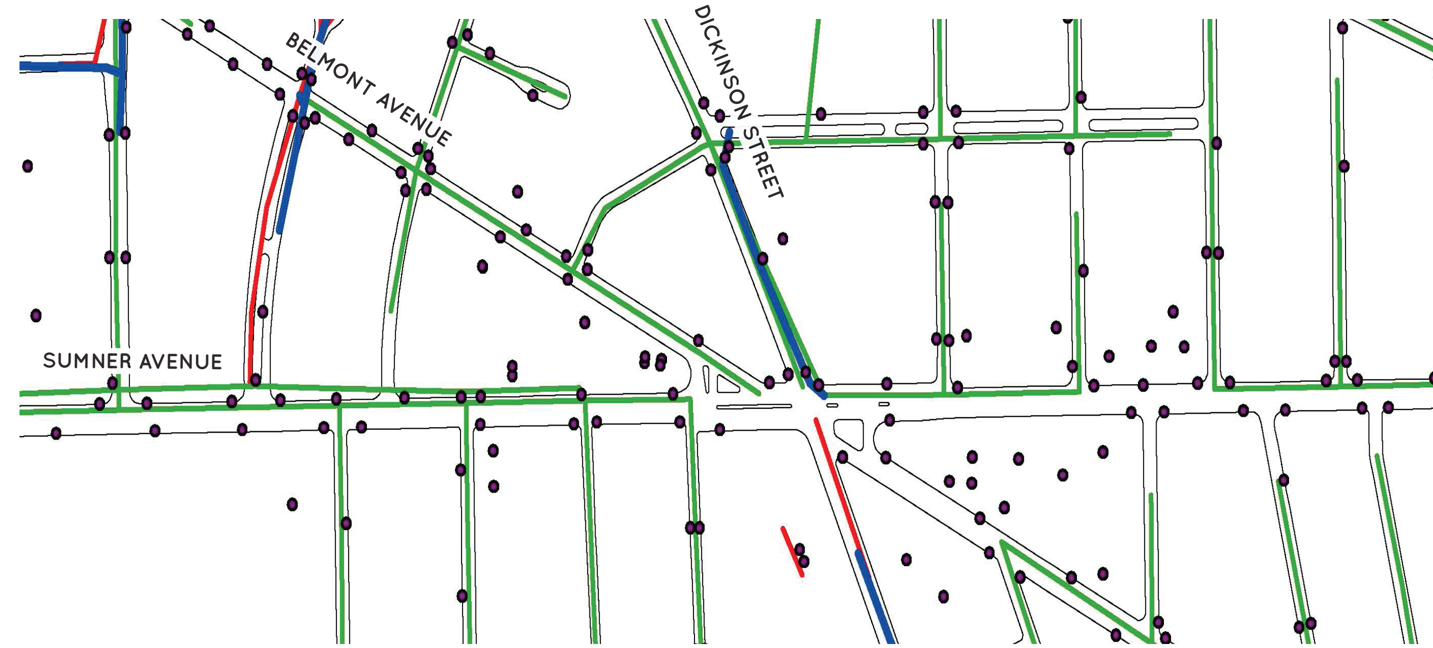
When rain falls on these hard surfaces it comes in contact with many kinds of pollution: heavy metals, automobile fluids, hydrocarbon fuel, fecal coliform bacteria, herbicides, insecticides, and more. These toxins dissolve or are physically picked up by the stormwater as it rushes down the street to the nearest sewer inlet. These substances are carcinogenic, hormone disrupting, immune suppressing and overall deleterious to human and ecosystem health. Once rainwater comes into contact with all these toxins it is no longer rain - it is has become a toxic, urban soup known as *runoff*.

This contaminated runoff needs to be cleansed before it is discharged into the Connecticut River and other local waterways. Since the project site has no intact wetlands to help remediate the runoff, the health of the Connecticut River is entirely reliant on conventional infrastructure. As these systems are insufficient during large storms, **including Green Street components in this heavily paved area will help to reduce the overall percentage of impermeable cover in the city, easing the strain on gray infrastructure within the X.**

Type of Surfaces in the "X"



The X has 82% impermeable (water resistant) surfaces and 18% permeable surfaces.



LEGEND
- Combined Sewer
- Sewer Only
- Stormwater Only
- Catch Basin Inlets

1000 Feet

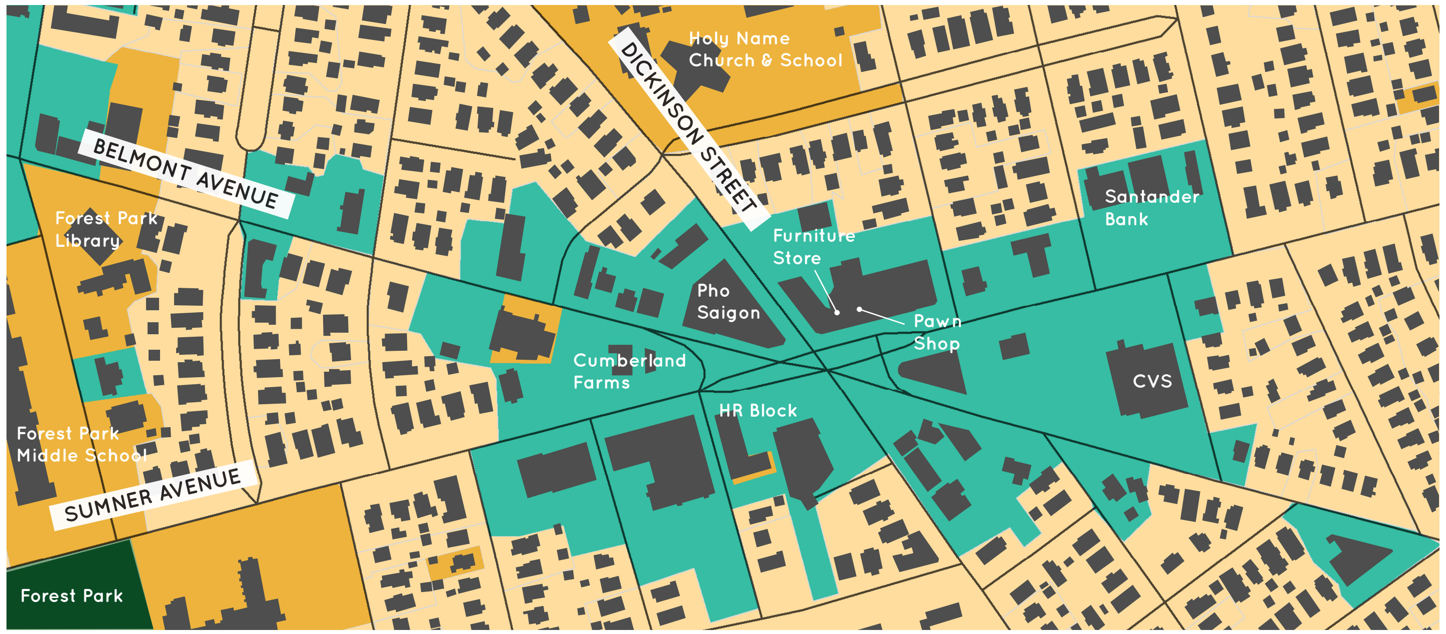
Illustrated in blue on the map above, separate stormwater sewers (SSS) drain runoff from south of the X intersection on Dickinson Street and discharge into a wetland area located off-site in Forest Park. According to residents, the single-story retirement townhouse in that area sees occasional flooding. Green Street components may help reduce the demand on these separate sewers and improve the quality of life for these residents by reducing flooding events.

Represented in red lines above is the combined sewer system, a strategy that sends both household wastewater and surface runoff into the same pipe. As discussed above, these systems are adequate under dry conditions and during average rainstorms, but they tend to overflow in large rainstorms, discharging untreated sewage into the Connecticut River.

Uncoupling these sewers is possible but difficult and expensive. **Green Streets are a more cost effective alternative to uncoupling combined sewers in order to satisfy the Environmental Protection Agency (EPA) mandate.** They also have many additional benefits.

Inlet on Belmont Avenue

Site: Land Use



LEGEND

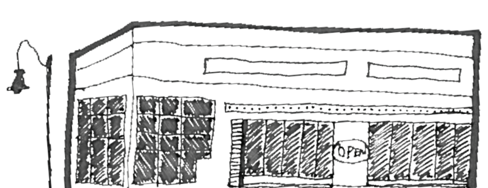
- Commercial
- High Density Residential
- Institutions
- Forest/ Woodlands

Land use within the X shapes the human experience. Commercial use is concentrated at the intersection of Sumner, Belmont and Dickinson with an array of businesses. Some are locally owned such as Quang's Barber Shop, Furniture Warehouse, the local Immigration Law Office, the X Pub and several Vietnamese restaurants; others are franchise stores such as CVS, Walgreens, Goodwill, H&R Block and the Cumberland Farms gas station. **Commercial use extends up and down Sumner and Belmont in both directions, but the rest of the X is defined by medium-high density residential areas.**

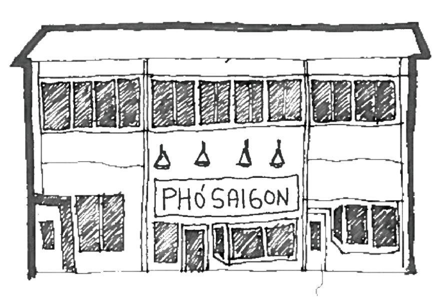
The Forest Park neighborhood still contains hundreds of early 19th century Victorian homes, although their single-use occupancy has been altered to allow for two and three-family units.

Throughout the central shopping and dwelling areas are pockets of public and religious institutions providing educational and cultural experiences, including Forest Park Middle School, Trinity Methodist Church and School and Forest Park Branch Library, etc. In the southwest corner of the project site is a small section Forest Park.

Furniture Warehouse



Pawn Shop



Pho Saigon

Site: Human Circulation

LEGEND

- Main Destination Areas
- Pedestrian Patterns
- Main Streets
- PVTA Bus Stops

The landscape of the X is dominated by pavement, cars, buses, noise and automobile exhaust. Nevertheless, the X is a heavily used pedestrian area, an indication that walking is a matter of necessity for some residents.

The inclusion of trees and other vegetation, in addition to the "Complete Street" safety improvements planned for the X, will help make the pedestrian experience more enjoyable, which is especially valuable to those who have no other means of transportation.

The most heavily used pedestrian corridor is on the main streets of Sumner and Belmont that have bus stops, grocery stores, schools, and other institutions.

Vehicles mainly use the X intersection as a route from East Longmeadow to Downtown by Belmont Avenue or from the east side of Springfield to the west by Sumner Avenue in order to connect to I-91. According to some residents, locals use Lenox and Cliftwood Street as alternative routes to avoid the X intersection altogether.

The franchise businesses at the X intersection — Dunkin Donuts, CVS and Walgreens — provide large parking lots and drive-thrus that give preference to cars over pedestrians.

Crossing Guard at the X

Summary Analysis

Citywide analysis revealed that the X intersection has a high percentage of impermeable surface compared to other areas outside of Springfield's Metro Center. These impermeable surfaces generate large amounts of runoff that overflow directly into the Connecticut River and negatively impact water quality. Furthermore, the X is a high traffic commercial hub within the neighborhood. This makes the X intersection the ideal location to construct green infrastructure to intercept, infiltrate and cleanse the polluted stormwater. The following site patterns have been identified as major factors that will guide the design recommendations:

Impermeable & Roof Surfaces

The site is covered by 82% impermeable surfaces such as asphalt streets, concrete sidewalks, shingled or tar roofs and parking lots.

Commercial and Institutional Use

Land use at the X intersection is 50% commercial and institutional use; restaurants, retail, drugstores, gas stations, professional businesses and social services cater to the neighborhood's high minority and low-income population.

Stormwater Drain Only

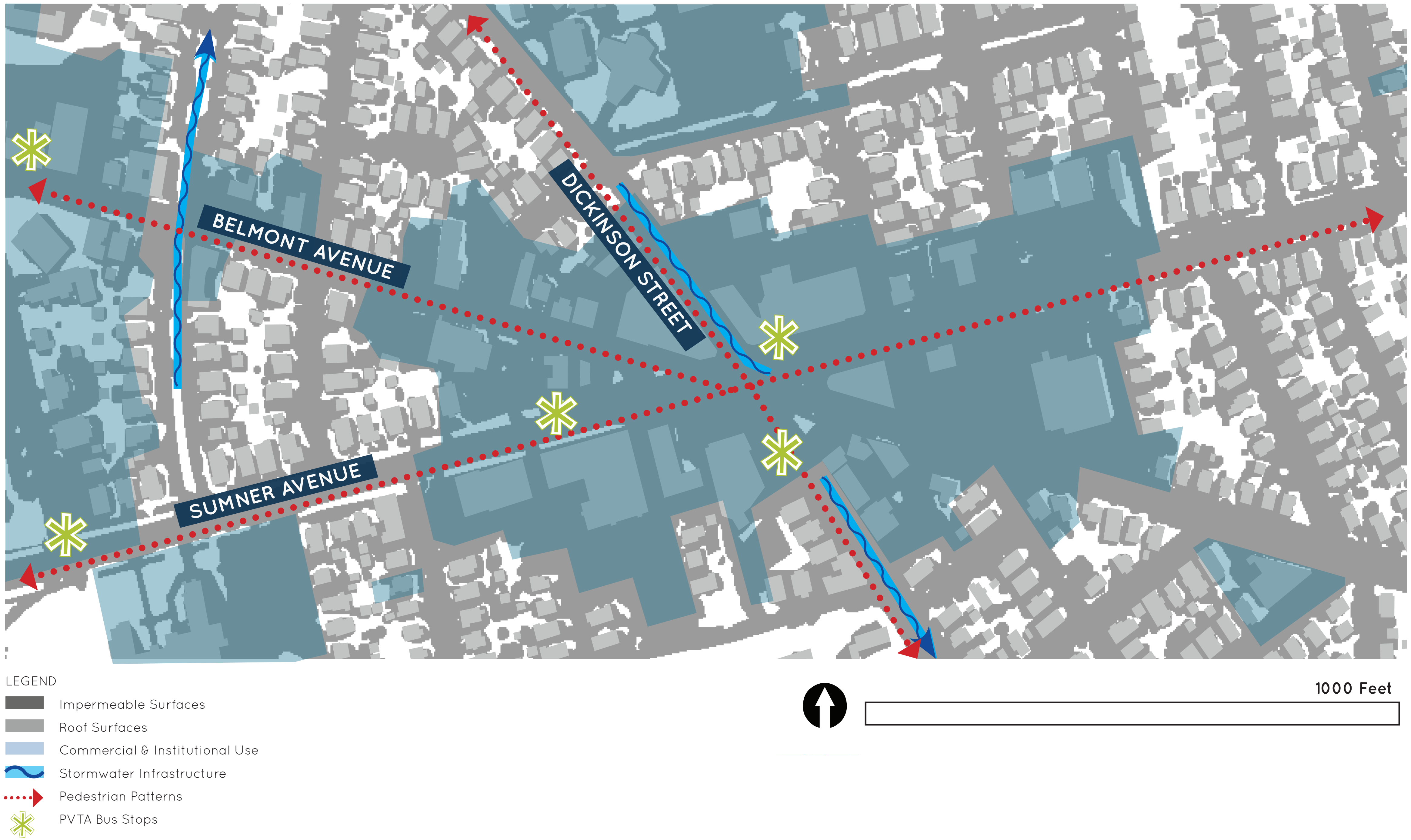
Springfield's sewer system, like many old industrial cities has a combined sewer system (CSS) which collects and combines household wastewater and rainwater into one system and is liable to overflow. Most of the X uses a CSS although there are three (3) locations nearby that have separate stormwater sewers (SSS).

Pedestrian Patterns & (PVTA) Bus Stops

The X is dominated by vehicles but also heavily occupied with pedestrians who walk or bike to neighborhood businesses and educational institutions, or wait for the local Pioneer Valley Transportation Authority (PVTA) buses to travel throughout the city and beyond.

Existing Tree Canopy

Mature canopy is sparse and along Sumner trees are spaced widely, leaving many streets without significant shade, increasing the urban heat island effect.



GREEN STREETS

TOOLBOX

Tree Box Filter

A tree box filter is a prefabricated concrete container filled with engineered soil designed to accommodate a large influx of water. The box is underlaid with gravel and a drainage pipe and planted with a small tree. Runoff enters from an inlet on the street and percolates through the soil, catching sediments and visible trash.

Tree root systems soak up and decontaminate water, transpiring organic pollutants such as hydrocarbons and sequestering inorganic pollutants such as heavy metals. The container can be bottomless to encourage infiltration in sandy soils or closed in soils that do not infiltrate water adequately. (Toolkit 1).

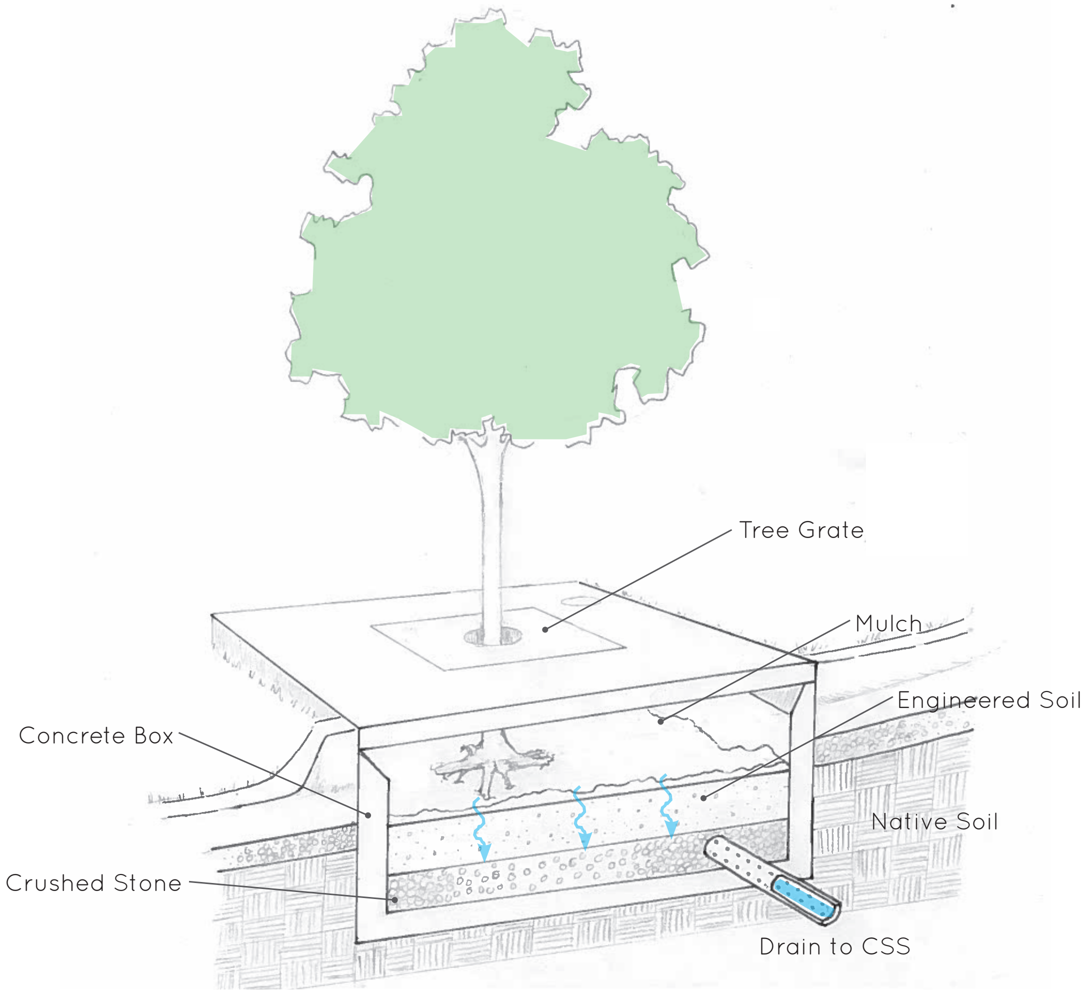
According to the University of New Hampshire Stormwater Center, these compact systems are effective at removing total suspended solids (93% removal), total petroleum hydrocarbons (99 % removal), nitrogen (38-65%), phosphorus (50-80%). They sequester heavy metals such as zinc (78% removal) and are capable of treating water effectively in all four seasons. (Rector)

Each 8' by 6' tree box filter is designed to treat approximately .25-.5 acres. (Rector) Due to the small size of these systems, however, tree box filters do not significantly reduce peak flow unless used in freely draining soils where stormwater can infiltrate quickly.

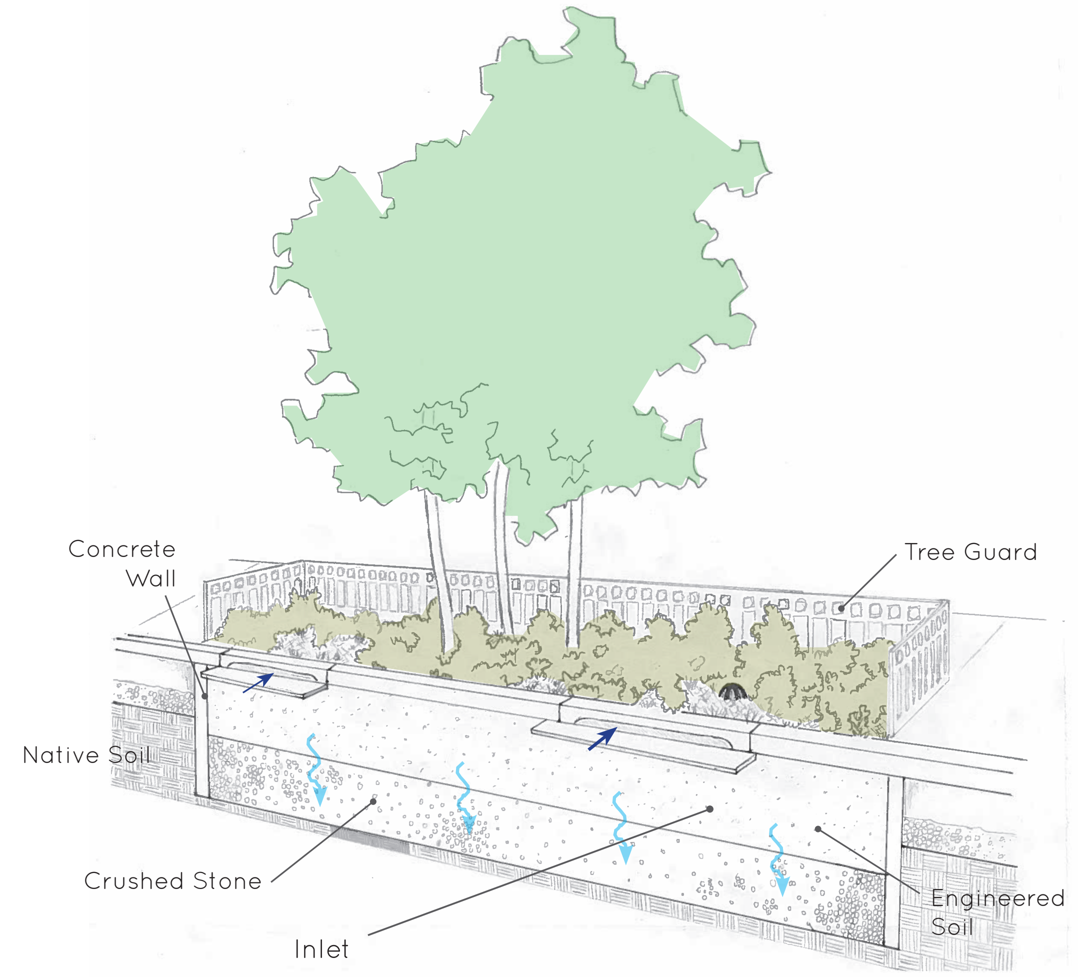
Also, because of their limited soil volume, trees species are limited to smaller selections that have to be replaced on an average of 5-10 years. (EPA Stormwater 11) Tree boxes themselves have an average life span of 25 years. (Rector)

Maintenance

Tree box filters are fairly low maintenance, requiring only periodic trash removal, biennial replacement of mulch and inspections to ensure that the bypass and soils are actively conveying water. Tree box filters are the lowest maintenance system included in this toolbox, a clear advantage over alternative systems.



Tree Trench



A tree trench is similar to a tree box filter, a concrete box filled with engineered soil that cleans and filters runoff and has a high percentage of void space with a large capacity to store water.

Water enters from an inlet in the street curb and moves across and down into a living medium of organic soil matter and tree roots which helps to break down and sequester toxins.

The box is lined with a permeable geotextile fabric, underlaid with stone or gravel and planted with a variety of street trees. They can be "open" (above) or"covered" by permeable pavement which enables pedestrian accessibility.

A tree trench is longer than a tree box filter, which provides more soil volume and allows trees to grow larger, healthier and provide more benefits to the city. Research shows that tree size and vitality have a direct connection to the soil volume given to its root systems. If the system is fully saturated, stormwater running along the gutter will bypass the inlet and flow into a conventional sewer (Philadelphia GI 1). In this way, green and grey systems can be linked together, to cooperate and share their benefits.

These systems require deep excavation to create adequate storage space, and therefore are unsuitable for areas with shallow buried utilities, which should be protected from water and root penetration (EPA Stormwater 11).

Maintenance

Uncovered tree trenches demand irrigation and weeding during the establishment of selected plants. Covered trenches only need seasonal vacuuming of permeable surfaces.

Example of an easily maintained covered tree trench on Washington Avenue in Philadelphia, PA

Stormwater Planter

A stormwater planter is an elongated concrete planter with an open bottom and high walls that collects water from the road via a "curb cut" or from redirected downspouts. The planter is lined with a permeable geotextile fabric, filled with engineered soil, underlaid with gravel and stone, and populated with a community of plants.

These systems are functional in small spaces because they are often more compact than a tree trench but can be designed to intercept large amounts of water. Like most other green infrastructure systems, if inflow overwhelms the capacity of the system it can bypass the street inlet or escape via the overflow pipe and spill into an existing sewer pipe connected to the grey infrastructure system. In such a case, the stormwater planter still retains the benefit of retarding the surge of water flowing into the combined sewer system, reducing the peak flow and the likelihood of a CSO event. These systems are only suitable in soil types that drain freely.

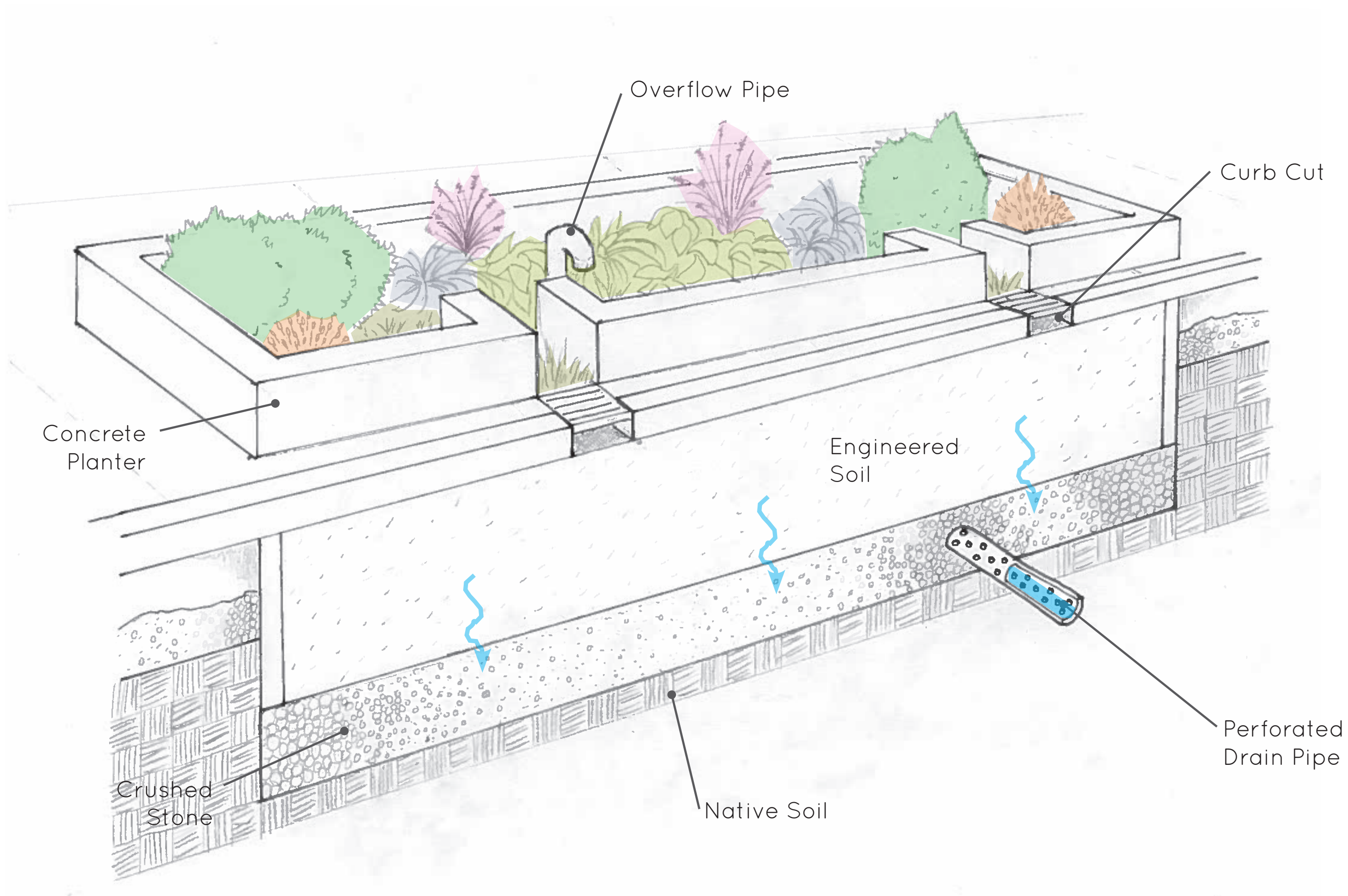
This system easily serves as a "learning landscape" with signs describing what birds, butterflies, and bees, may be attracted to the plants. In such instances a planter can be especially aesthetic and the high concrete walls can be integrated with seating designs to create a unique resting place.

Maintenance

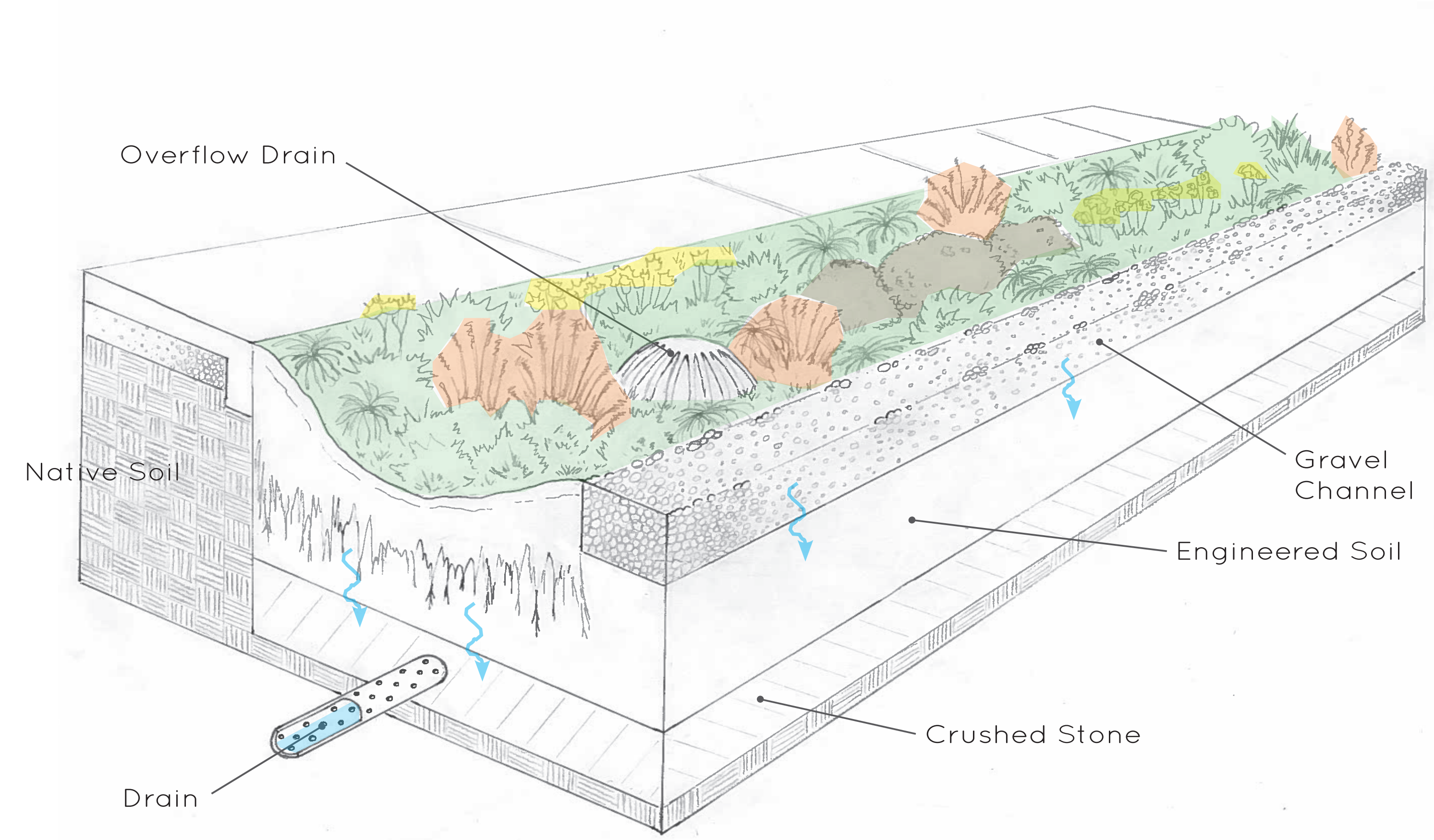
Water should drain from planters within 3-4 hours of a storm event. Topsoil may need replacing if water begins to drain poorly over time, or sediment accumulation can be removed by hand in order to not damage established plantings.

Weeding invasive or unwanted species and removing litter may be necessary, especially before vegetation becomes established.

Downspouts connected to planter must be checked periodically to ensure unimpeded collection from roofs (O&M Portland 2).



Bioswale



A bioswale is an open, sloped, vegetated channel that treats runoff as it is conveyed across a community of plants.

"The main function of a bioswale is to treat stormwater runoff as it is conveyed, whereas the main function of a rain garden is to treat stormwater runoff as it is infiltrated" (LID Manual, 182). Because of this, if the bioswale is located in an area of high percentage impermeable surface such as the X, it should be designed to discharge into another green streets component, such as a rain garden, or back into the combined sewer system [EPA Stormwater 27].

These systems are especially suitable to harvest sheet flow from large areas such as parking lots. A channel of gravel along the edge of the bioswale captures sediments before runoff enters the main swale. They may require specific measures to catch water, such as curb cuts or gutters (LID Manual 182). In clay soils or compacted urban fill they may also require an underdrain, or an overflow grate for periodic, particularly heavy rain events.

Construction details are flexible as these systems can be built without the use of concrete.

Maintenance

Bioswales vary in size, but are generally larger than tree trenches and able to contain large urban trees. Due to their size, weeding is a significant concern during the establishment of selected plants and extensive weeding with hand tools may be required. Irrigation may be necessary during the first year or during prolonged drought.

After extreme rain events, these systems should be inspected for erosion, accumulation of debris or sediment and general damage. Flooding may also displace noxious weeds into the swale from outside the system.

A beautiful yet functional bioswale on Grange Avenue in Greendale, WI

Rain Garden

A rain garden is a vegetated depression designed to capture, hold and gradually infiltrate stormwater into the landscape within 72 hours of a rain event (LID Manual 178).

These systems are gaining popularity across the country because of their flexibility and ecosystem benefits. They are suitable for residential, commercial or public properties. They can be large or small, with hard sides or soft, with a gravel bottom and underdrain or overflow. They can be planted with large trees, if space allows, or with herbaceous perennials.

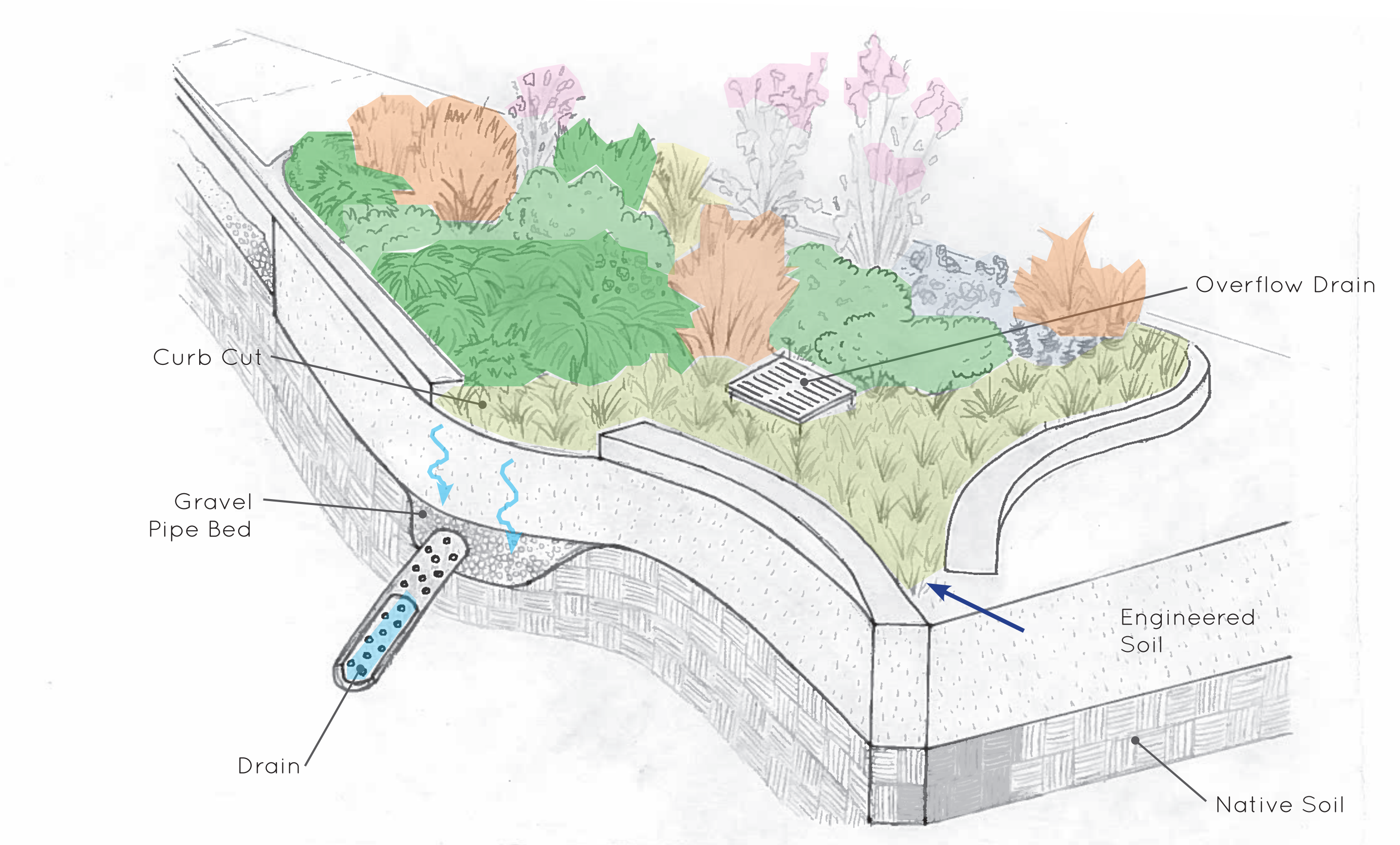
A rain garden effectively filters toxins and helps to attenuate the peak flow of a storm event by delaying the surge of runoff across a landscape. They do not, however, mitigate very large storms. “These facilities can handle only one to two year storm events, requiring connection to a treatment network for larger events” (LID Manual 104).

These systems should be ideally 18” deep and allow for 6-12” ponding depth (HGS 16).

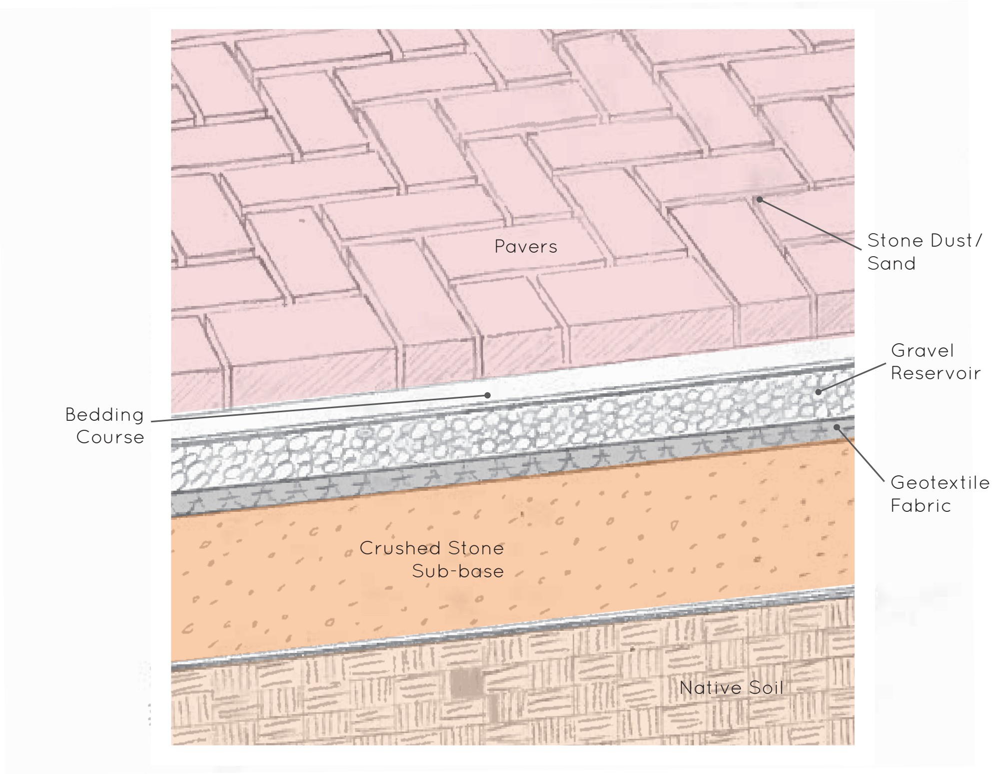
Maintenance

In the first year of operation, rain gardens demand irrigation as plants establish their root systems. Depending on species selected, monthly pruning and weeding as well as removal of accumulated trash and debris are necessary.

Annual demands include inspection of inflow area for sediment accumulation and replacement of dead plants. Mulch should be replenished every two to three years. (Bluewater 1)



Permeable Pavement



Permeable pavements are specially designed to allow water to penetrate. Because water freely drains between the pavers, water is less likely to accumulate on the surface (EPA Stormwater 24).

Interlocking concrete unit pavers allow water to infiltrate through the gaps and infiltrate into a basin of gravel and then trickle into the ground. The gaps can contain fine gravel or grass and serve as temporary parking. Because unit pavers can be reset without damaging the individual blocks, these systems are cost effective in areas that may need occasional repair.

Yet another technology is permeable asphalt and concrete, which are mixed with coarse sand so that water flows directly through them. Permeable pavements are not appropriate in areas that receive high volumes of traffic or large pollutant loads because stormwater is not treated prior to infiltration. (LID Toolkit FS3) They should not be used on areas of greater than 5% slope. Snow plows can catch the edge of unit pavers and must be equipped with rollers. Likewise, heavy sand use in winter may clog joints and void space, rendering areas ineffective (LID Toolkit, FS3). So, salt and sand use should be kept to a minimum.

Maintenance

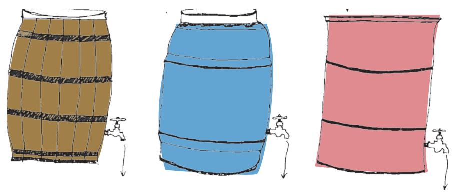
Springfield could use the X as a suitability study for implementing permeable pavements throughout the city. Maintenance is an occasional but necessary job to keep porous pavement from getting clogged and demands a specialized vacuum sweeper. More permeable surface area across the city increases an economy of scale that helps to offset the capital cost of renting or purchasing this machinery.

Clogging rates are dependent on traffic frequency, surrounding soil permeability and, of course, frequency of maintenance. Modular pavers can be removed and replaced easier than traditional pavements, which implies less expensive subsurface repairs and provides cost savings over the life span of the system.

An permeable parking lot with infiltration planters in Carol Stream, IL

Rain Barrel & Green Roof

Rain barrels come in a variety of shapes and sizes, but the approach is the same — stormwater is collected from the roof to be saved for future use.



Citywide application of rain barrels can be thought of as a series of miniature dams that reduce the peak discharge of a storm.

Rainwater is used as a resource to irrigate gardens or other non-potable uses. Although these systems do not improve water quality, they do intercept rainwater before it is polluted by the street.

These systems are relatively inexpensive, easy to install and require little maintenance. They can be set up to drip drain gradually and should be emptied completely between storms in order to maximize their capacity for the next rain event. Barrels should also be emptied in winter and kept covered during the summer to prevent mosquitoes.

Some cities incentivize rain barrels in their community in order to encourage citizen adoption. Springfield could subsidize the cost and help install demonstrations for these systems. For example, a resident who successfully installs a rain barrel catchment system could receive a rebate compensating them for a portion or all of the barrel's cost.

A green roof contains vegetation growing in a lightweight engineered soil on top of a waterproof plastic membrane. The soil encourages the absorption of water, which is taken up by plants and transpired into the air (LID Toolkit FS9).

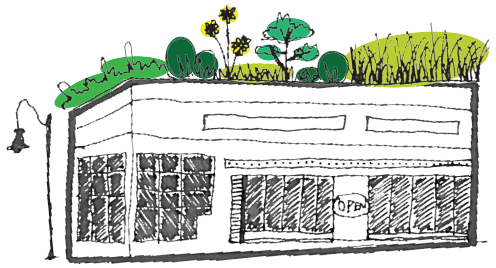
According to The Center for Green Roof Research at Penn. State University, a 4" green roof can retain 50% of total rainfall for a 1-2" storm. Peak flow rates are reduced by 50-90% compared to conventional roofs, and peak discharge is delayed by an hour or more.

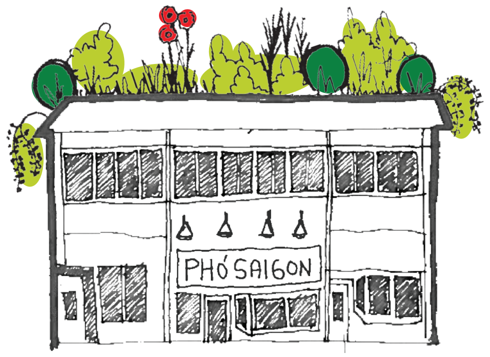
Some communities such as Portland, Oregon have begun incentivizing green roofs, funding $5 per square foot for new installations (Portland GI 1-4). These systems have wide applicability in Springfield, which has over 2,000 acres of roof across the city.

These systems provide benefits beyond peak flow attenuation. A green roof provides natural insulation, reducing heat loss in winter by 25% while also prolonging the life of the roof since it shields the surface from UV rays and thermal stress. Vegetation improves air quality, enhances the appearance of the building and reduces the urban heat island effect.

Structural studies of existing buildings should be performed to ensure suitability. These systems also require occasional fertilization and weeding, especially during the establishment phase.

Green roof overlooking the city skyline in Toronto, Canada





Planting List

SAMPLE PLANTING LIST

A planting list will vary based on following: type of green infrastructure feature, the amount of sunlight or shade, the size of the feature, the depth of the soil volume, and the amount of water the feature is expected to infiltrate. Below are a few suggested plants, especially for the rain garden, bioswale, open tree trench or stormwater planter features.

TREES

. Red maple *(Acer rubrum)*
. River birch *(Betula negra)*
. Hawthorn *(Crataegus monogyna)*
. Amur Maackia (Maackia amurensis)
. Swamp white oak *(Quercus bicolor)*
. Pin oak *(Quercus palustris)*
. Cottonwood *(Populus deltoides)*
. Japanese Tree Lilac *(Syringa reticulata)*

SHRUBS

. Serviceberry *(Amelanchier alnifolia)*
. Red osier dogwood *(Cornus sericea)*
. Inkberry (Ilex glabra)
. Winterberry *(Ilex verticillata)*
. Spicebush *(Lindera aestivale benzoin)*
. Arrowwood *(Viburnum dentatum)*

GRASSES

. Big bluestem *(Andropogon gerardii)*
. Tussock sedge *(Carex stricta)*
. **Tufted hairgrass (Deschampsia cespitosa)**
. Redtop panic grass *(Panicum rigidulum)*
. Switch grass *(Panicum virgatum)*
. Wool grass *(Scirpus cyperinus)*

PERENNIALS

. New York aster *(Aster novae-belgii)*
. Virginia Wild Rye *(Elymus virginicus)*
. Joe Pye weed *(Eupatorium fi stulosum)*
. Iris (Iris versicolor)
. Cardinal flower *(Lobelia cardinalis)*
. Royal fern *(Osmunda regalis)*
. Black-Eyed Susan *(Rudbeckia birta)*
. Blue Vervain *(Verbena hastata)*

CASE STUDY

The X

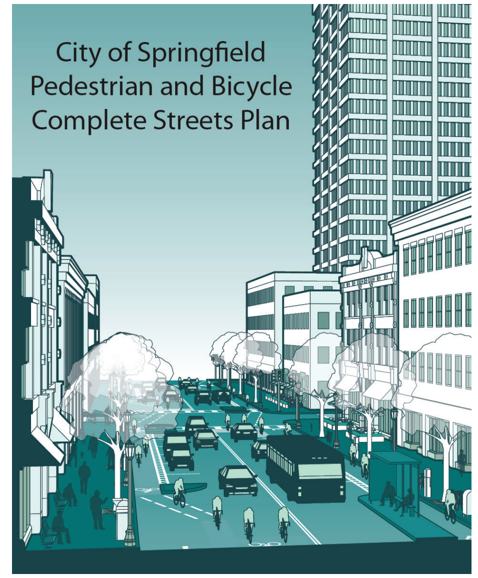
Why the X?

In order to improve safety and traffic flow at the X intersection, the city worked with the engineering firm Tighe and Bond to design the proposal below. These designs will continue to be refined. They serve as the backbone for specific recommendations for green infrastructure at the intersection.

These designs incorporate guidelines from the Complete Streets Plan recently published by the city. This reconfiguration of the street layout strives to accommodate all users, regardless of ability or mode of transportation.

The most significant changes include the transformation of Belmont into a one way street between the two newly created roundabouts. This liberates substantial portions of the right-of-way to be used as two large pedestrian plazas, one northwest of the intersection, the other southeast.

Because of the diversity of street typologies and land use zoning, the X serves as an exemplar case study to instruct and inspire further Green Streets across the city.



New "complete street" designs attempt to make the intersection safer to all users - pedestrians, cyclists, drivers and bus passengers.

Tighe and Bond Engineers, Inc

Public Meetings

In an attempt to understand the needs of the residents and users of the X, two participatory design meetings were held at the Forest Park Branch Library.

In the first meeting, on February 11, 2015 at 4:30-6:00pm, a brief informational session on the benefits of urban trees was presented by Dave Bloniarz by ReGreen Springfield. Afterward the Conway School team presented a short summary of the problem of combined sewers in Springfield. Then, participants were asked three questions:

1. Where do you gather at the X?
2. What catches your eye?
3. Where would you like to plant trees or place green stormwater features at the X? Why?

Although some participants responded that they like to occasionally shop or dine at the X, the consensus seemed to be that, in fact, there was nowhere pleasant to gather. The X was a space to move through, but not linger.

Some negative aspects that caught people's eye included the traffic, trash in the streets, run down areas and lack of vegetation. Positives included the new facades of some buildings, and the landscaping at CVS and Dunkin Donuts, which was seen as well cared for and beneficial for the neighborhood.

At the second meeting, two weeks later on February 29 at 3:30-5pm, two alternative preliminary designs were presented to gauge preferences of the participants. The first alternative prioritized community gathering spaces; the second maximized green space at the intersection.

Although there was significant interest in maximizing green space, many participants voiced strong concerns about the maintenance of these systems. Although beautiful, some installations were seen as too complex and likely to collect trash.

Designs for the intersection should incorporate this feedback, encouraging gathering space while balancing green space and ease of maintenance.

PUBLIC MEETINGS PHOTOS

Forest Park Branch Library, Springfield, MA

Participants' Feedback:

. Community Areas
. Seating
. Reduce Traffic
. Entertainment
. Maintenance of Infrastructure
. Improve Safety
. Landscaping
. Parking Lot Signs
. Trash Bins

Methodology

The complete streets guidebook categorizes streets by traffic speed, volume and the width of the right-of-way. This method of categorizing streets shows that there are five different types of streets in the X neighborhood.

Categorizing streets in this way helps inform which best management practices apply, (see table on the opposite page.)

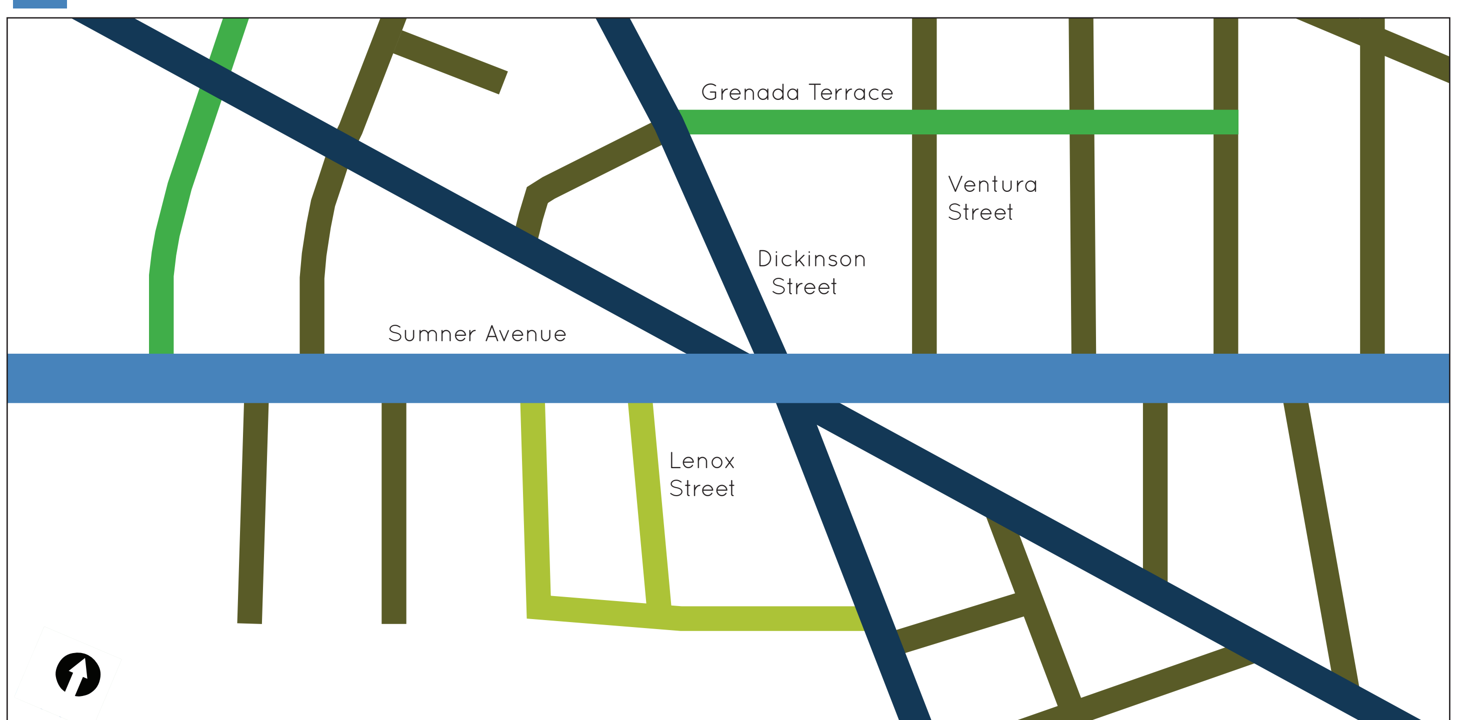
This technique was inspired by the Green Streets Guidebook for Holyoke, written by Conway School students Michele Carlson, Willa Caughey and Nelle Ward in Winter 2014.

STREET CHARACTERISTICS

Complete Street Type	Example of X Street	Public Right-of-Way	Driving Lane	Tree Belt	Land Use
Yield Street	Lenox Street	40' ft wide	(2) 12' ft	(2) 3' ft	High Density Residential
Neighborhood Street	Ventura Street	50' ft wide	(2) 13' ft	(2) 7' ft	Low-Medium Density Residential
Neighborhood Main Street	Dickinson Street	60' ft wide	(2) 21' ft	(2) 3' ft	Multi-Family Residential
Residential Boulevard	Grenada Terrace	48' ft wide	(2) 18' ft	(2) 3' ft	Low-Medium Density Residential
Boulevard	Sumner Avenue	100' ft wide	(4) 15' ft	(2) 12' ft	Mix-Use Commercial

The 5 types of streets in the X:

- Yield Street
- Neighborhood Street
- Neighborhood Main Street
- Residential Boulevard
- Boulevard



In addition to street characteristics the best management practice metric is a guide to evaluate which toolbox features will be best suited to improve water quality and/or reduce the volume of stormwater for a selected area.

BEST MANAGEMENT PRACTICE METRIC

Tools	Highlights	Water Quality	Volume Reduction
Tree Box Filter	. Increase infiltration . Low maintenance . Best in commercial areas	Highly Recommended	Useful
Tree Trench	. Large soil volume for tree root systems . Increase infiltration . Best in commercial areas	Useful	Useful
Infiltration Planter	. Ideal for small spaces . Aesthetics . Best in commercial areas	Highly Recommended	Highly Recommended
Bioswale	. Harvest sheet flow . Serve as snow storage . Best in commercial areas	Highly Recommended	Highly Recommended
Rain Garden	. Aesthetics . Vary in size . Best in most areas	Highly Recommended	Highly Recommended
Permeable Pavement	. Increase infiltration . Cost effective . Best in low traffic areas	Useful	Highly Recommended
Rain Barrel	. Water storage . Low maintenance & cost . Best in residential areas	Not Recommended	Highly Recommended
Green Roof	. Natural insulation . Reduce heat island effect . Best in most areas	Not Recommended	Highly Recommended

Existing Trees

This project leverages funds from the Massachusetts Department of Transportation and the US Forest Service to plant trees within Springfield with the purpose of mitigating combined sewer overflows. The introduction of green infrastructure assists with municipal priorities to improve water quality in the Connecticut River and protect the health of human, plant and animal communities downstream.

Although this project seeks to maximize stormwater treatment components in the landscape, not every location is appropriate for these features, often because of the presence of an existing tree. **An inventory of existing trees (pictured on the right) mapped the height, canopy size, maturity and location of each tree within the project site. The results were two categories: large/mature trees (56) and small/ young trees (67). Over 120 trees where present in total.**

This inventory also found that, as one might expect, the thinnest concentration of trees was in the large acreage of parking lots in the neighborhood. These parking lots present significant opportunities for future tree planting and design initiatives

LEGEND

- Large/ Mature Trees (56)
- Small/ Young Trees (67)

Tree Box Filter Placement

The Massachusetts Department of Transportation (MassDOT) has prioritized the installation of tree box filters in statewide street reconstruction projects. Tree box filters offer easy connection to existing sewer infrastructure and their compact size makes them applicable in small spaces. As discussed earlier in this book, they require minimal maintenance once installed.

The criteria for tree box filter placement includes the site of current catch basins, existing trees placement, overhead power lines, and proximity to crosswalks, curbs and driveways. In addition, future tree growth must not block store signs.

Based on these factors, 45 locations were identified for tree box filters (see map to the right). 37 locations occupy existing catch basins, 4 require the removal of an existing small tree and another four 4 require additional infrastructure to connect to the sewer system.

In this project there is a special interest in retrofitting the city-owned parking lot on Dickinson Street to include green infrastructure, such as tree box filters and permeable pavement (see call out box in upper right corner).

LEGEND

- Ideal for Tree Box Filters (37)
- Replace existing tree for Tree Box Filter (4)
- Sewer connection needed for Tree Box Filter (4)

Other Toolbox Features

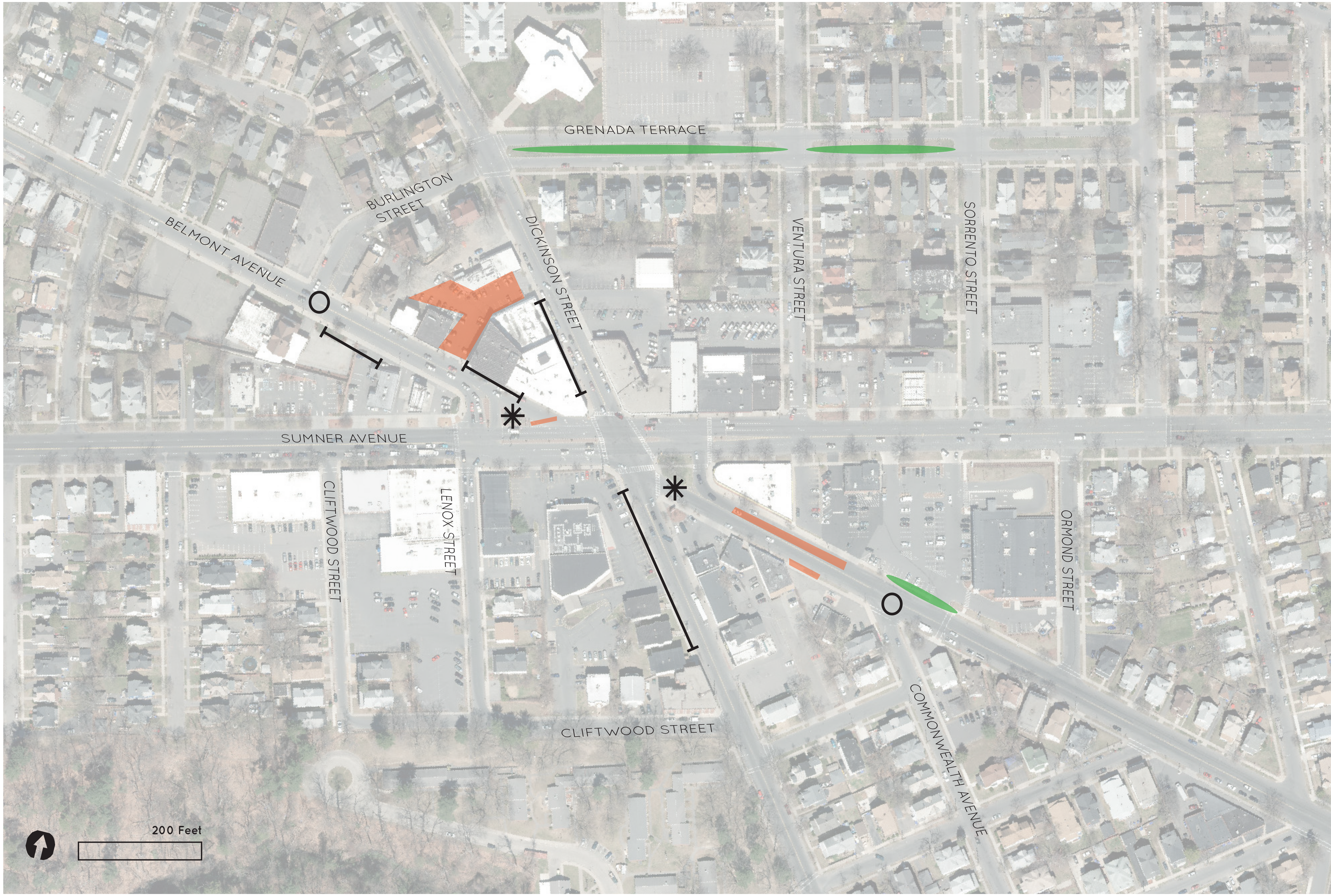
Although tree box filters are compact and easy to install, they are not ideal for every street. Other toolbox features – tree trenches, bioswales, stormwater planters, rain gardens and permeable pavements – provide a variety of options based on size, aesthetics and the peculiarities of each location.

Criteria for siting these features include the presence of existing trees and overhead power lines, existing street typologies and the volume of stormwater collected at each location. In the map on the right, the following features are placed within the project site: 4 tree trenches, 3 bioswales, 2 rain gardens, 2 planters with seating, and 4 areas with permeable pavement.

Refer to the toolbox section starting on page 26 or the best management practice metric on page 40 for more details regarding each feature.

LEGEND

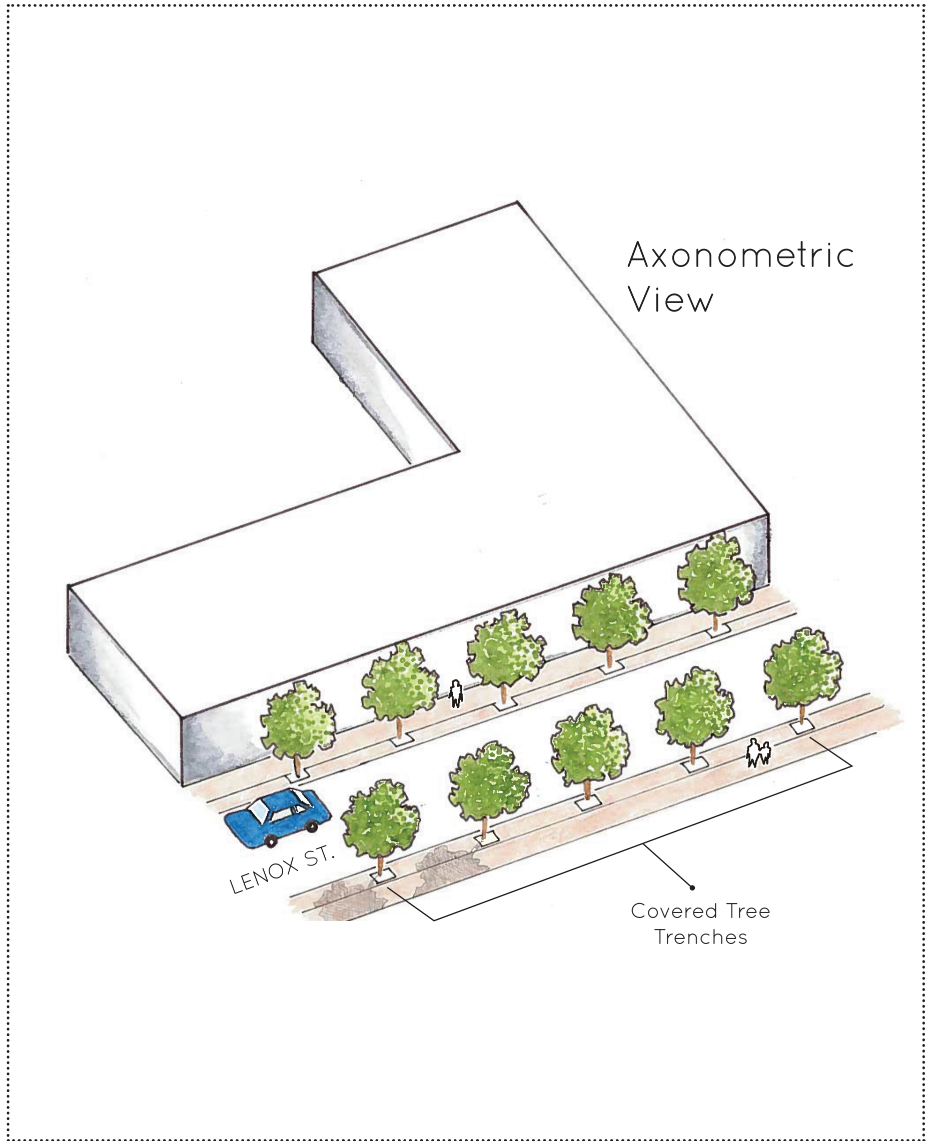
- Bioswale (3)
- Permeable Pavement (4)
- Tree Trenches (4)
- Rain Garden (2)
- Stormwater Planter (2)



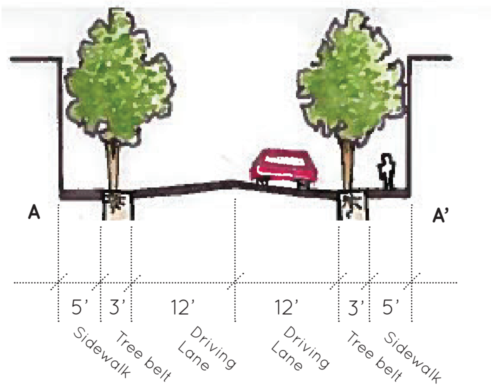
Yield Street: Lenox Street

Such a street should be crowned away from the center of the road, directing water to parallel parking spots along the roadside laid with permeable pavement. In such a narrow right-of-way, tree box filters are the most suitable strategy for decontaminating runoff.

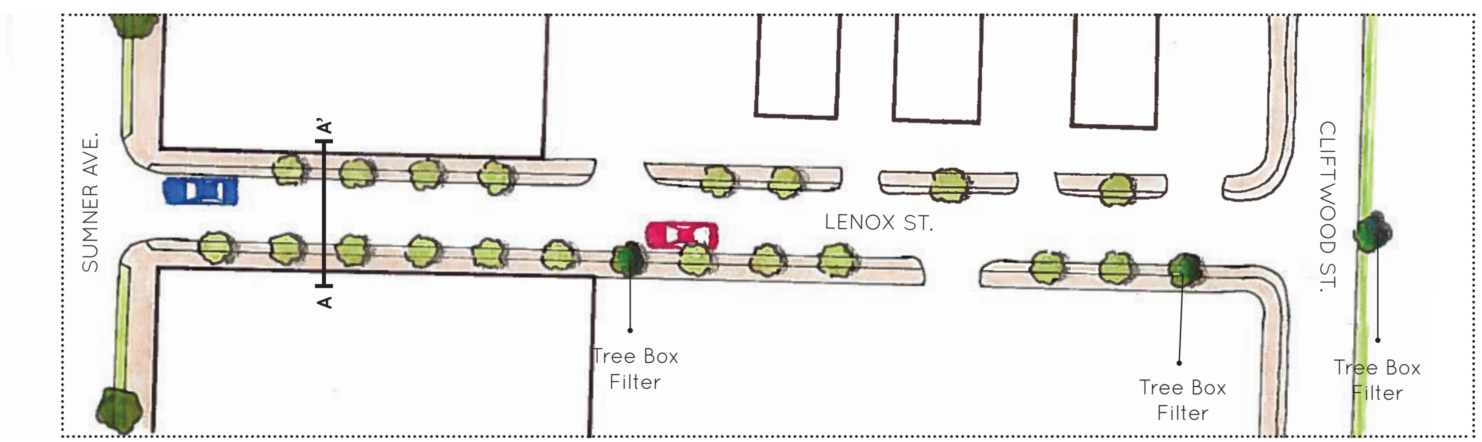
Lenox is currently 26 feet wide and contains two lanes going in the same direction. Reducing road width to the state minimum (of 10' per lane) is a strategy to maximize space for green infrastructure in these narrow corridors.



Section View



Plan View

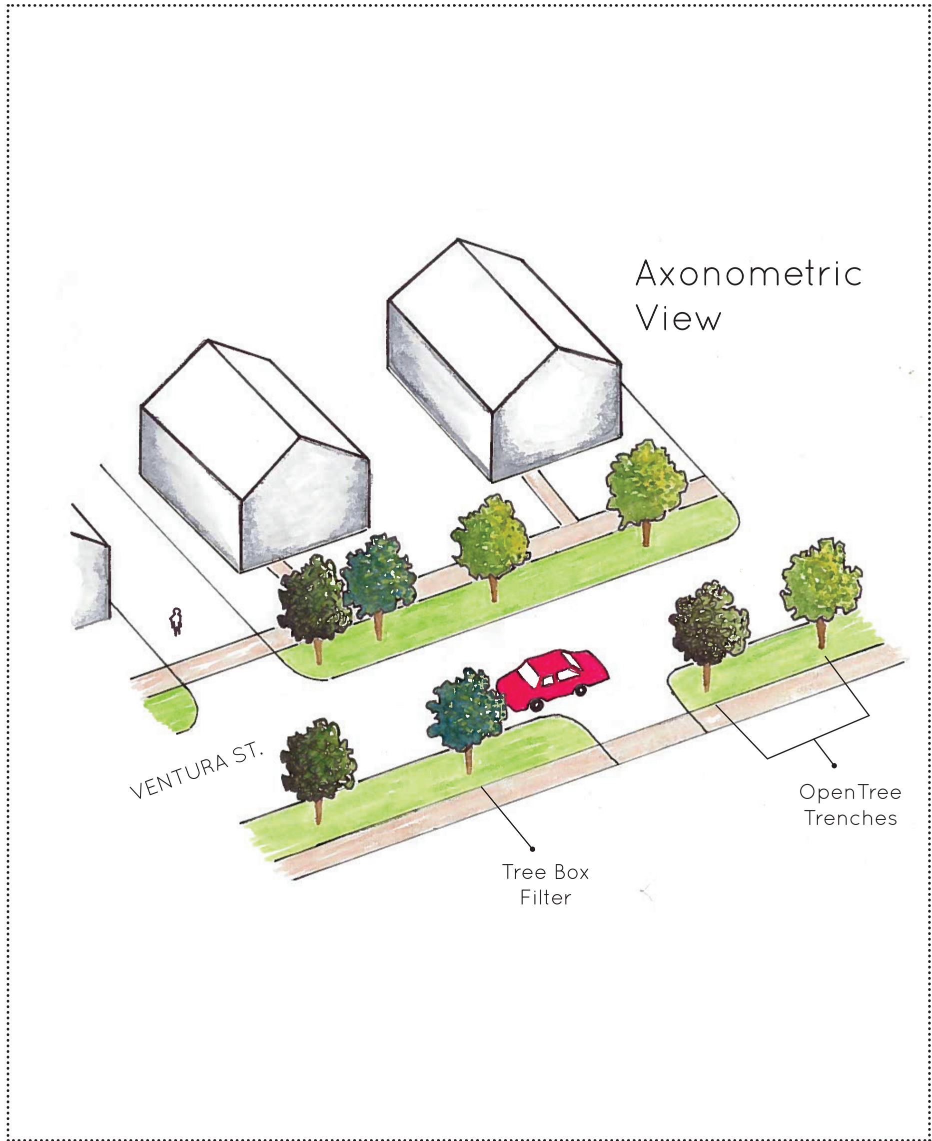


Neighborhood Street: Ventura Street

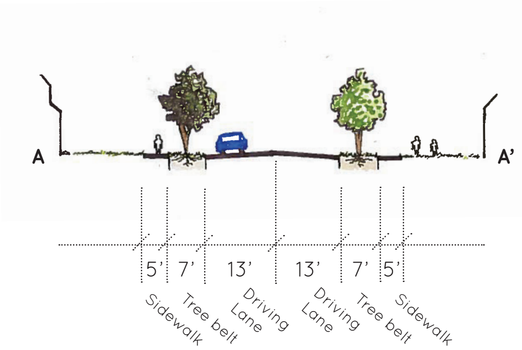
Like a yield street, a neighborhood street should be crowned away from the center of the road or "superelevated" - slanting from one edge of the right-of-way to the other, in order to direct water into green infrastructure features. Hard surface should be reduced to state minimums to reduce cost and increase green space.

These least traveled streets are most appropriate for permeable asphalt across the entire right-of-way. Alternatively, permeable asphalt could be used for parking only.

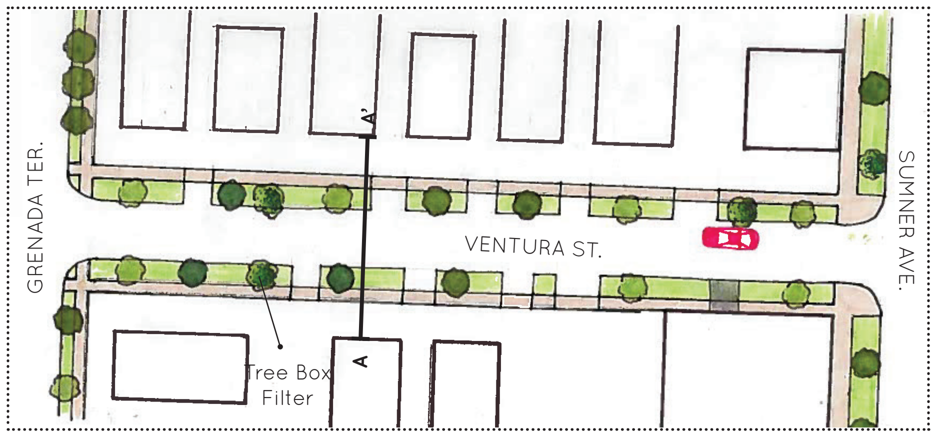
Encouraging rain barrels and rain gardens on private property would significantly attenuate peak flow of a rain event while also hydrating the residential landscape.



Section View



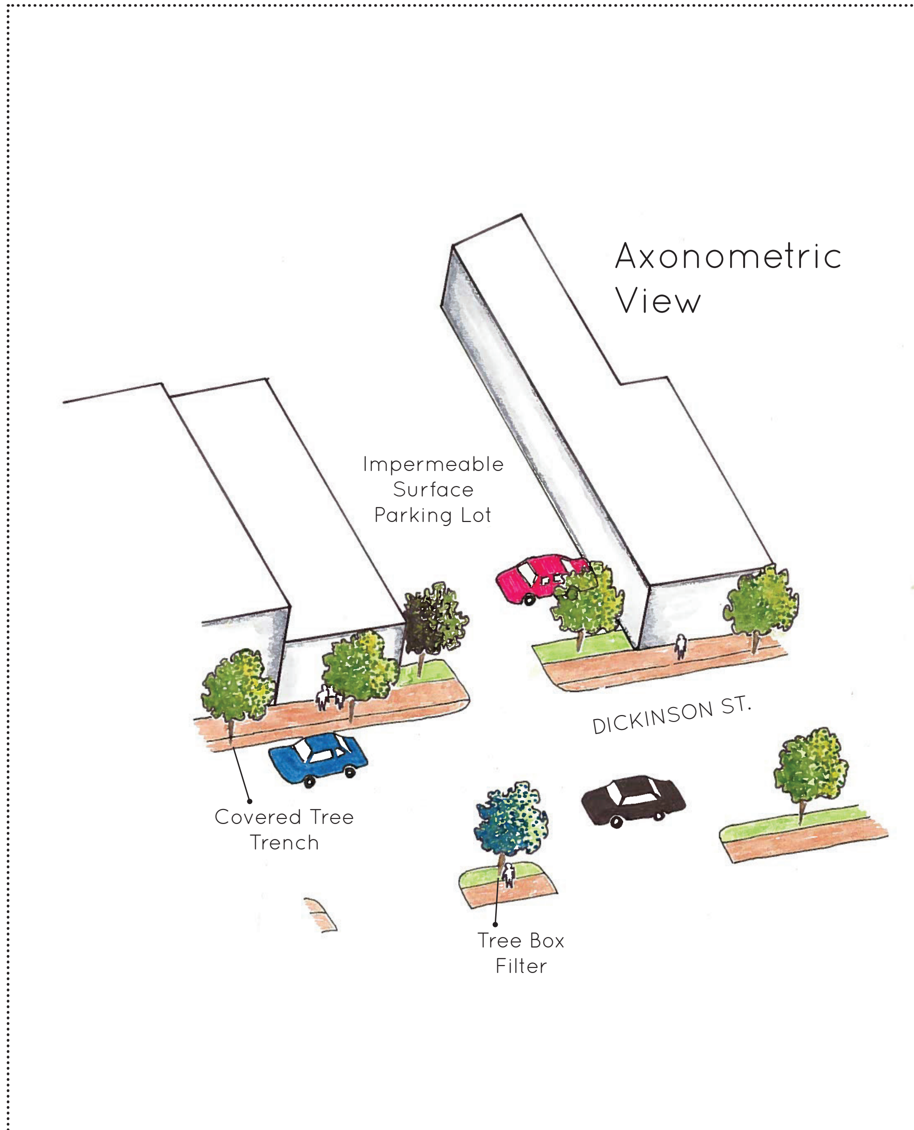
Plan View



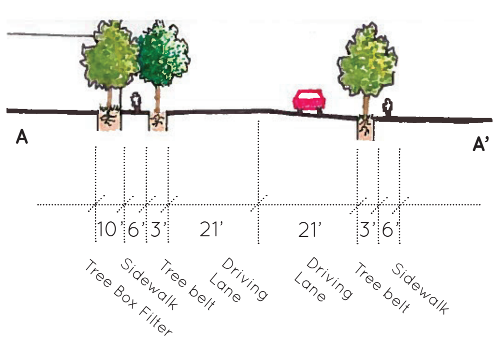
Neighborhood Main Street: Dickinson Avenue

High volume roads are less suitable for permeable asphalts, although these surfaces would be effective for parallel parking spaces wherever road width allows.

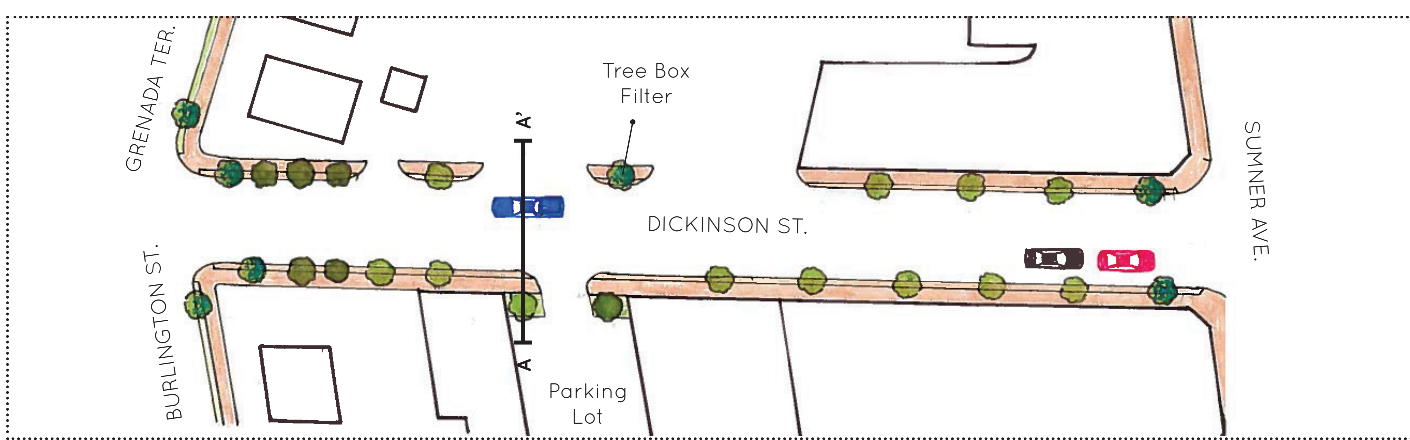
In such a narrow right-of-way, tree box filters and tree trenches are the most economical use of space and can decontaminate large amounts of water over time.



Section View



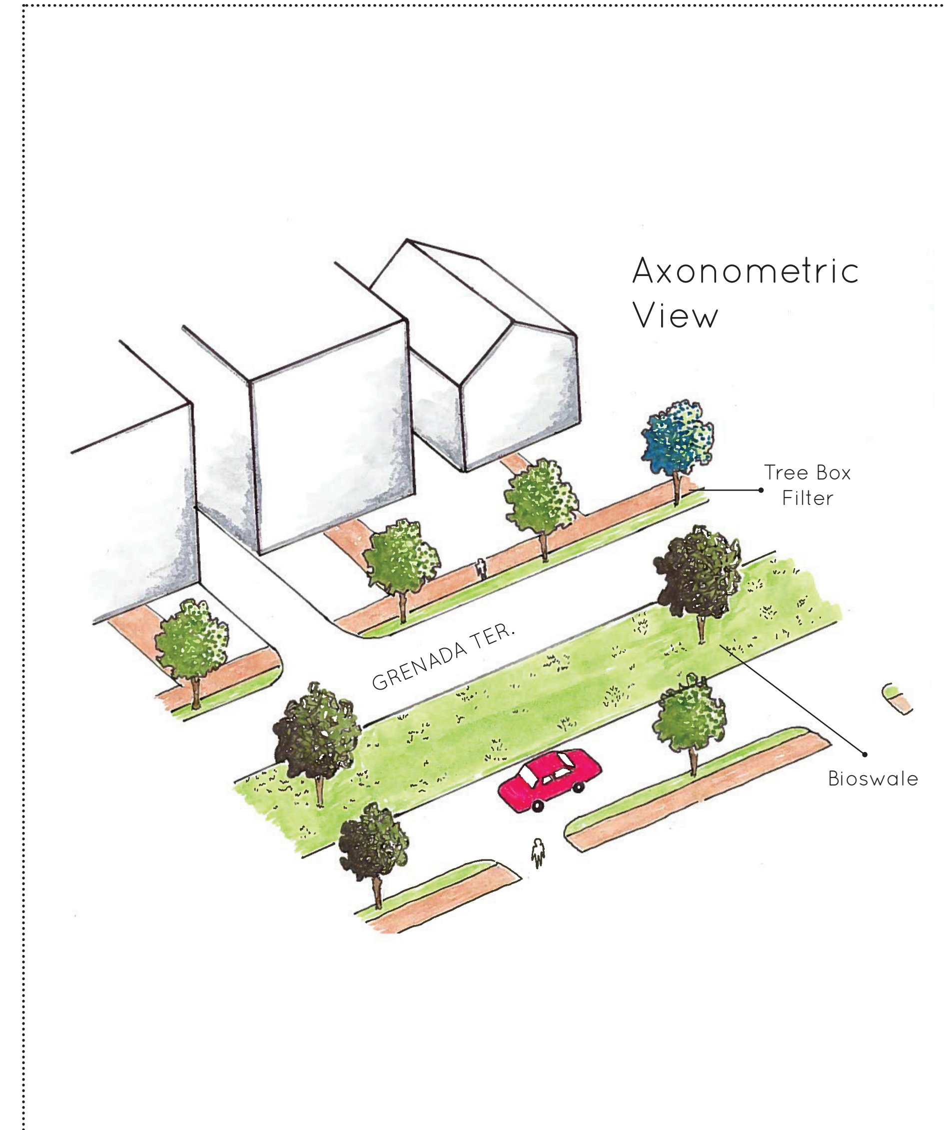
Plan View



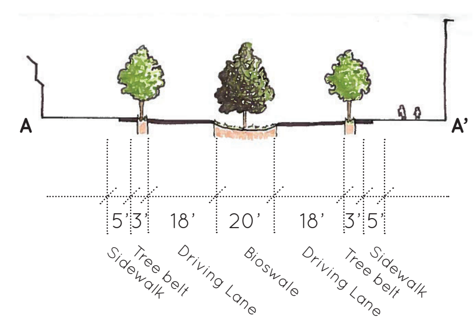
Residential Boulevard: Grenada Terrace

Low volume streets are most suitable for permeable asphalt. The street profile could be shaped to direct water into a tree-filled bioswale running down the center of the street within the median.

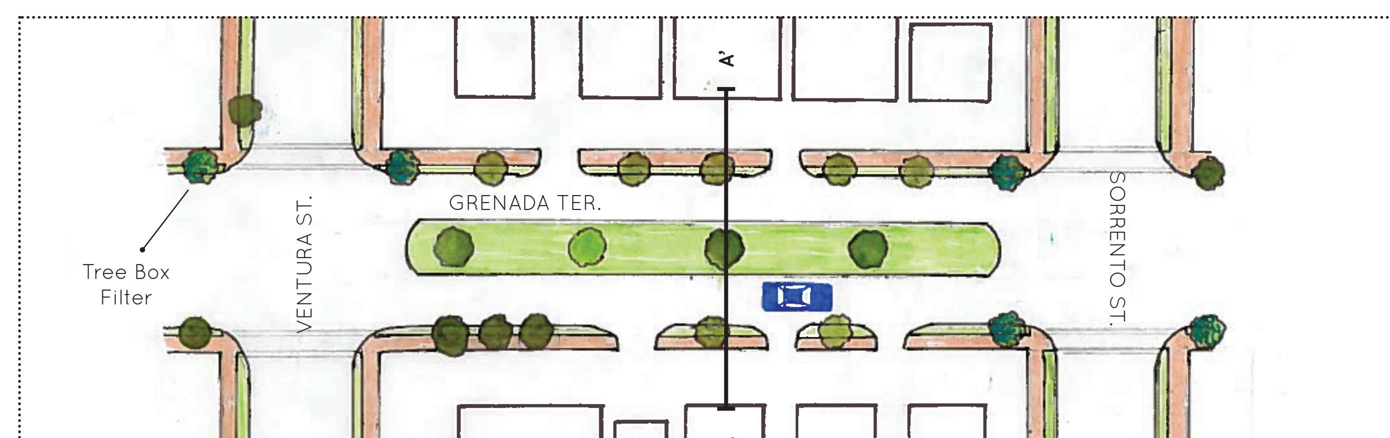
Larger street trees should be planted in the median to fill in the gaps in the canopy.



Section View



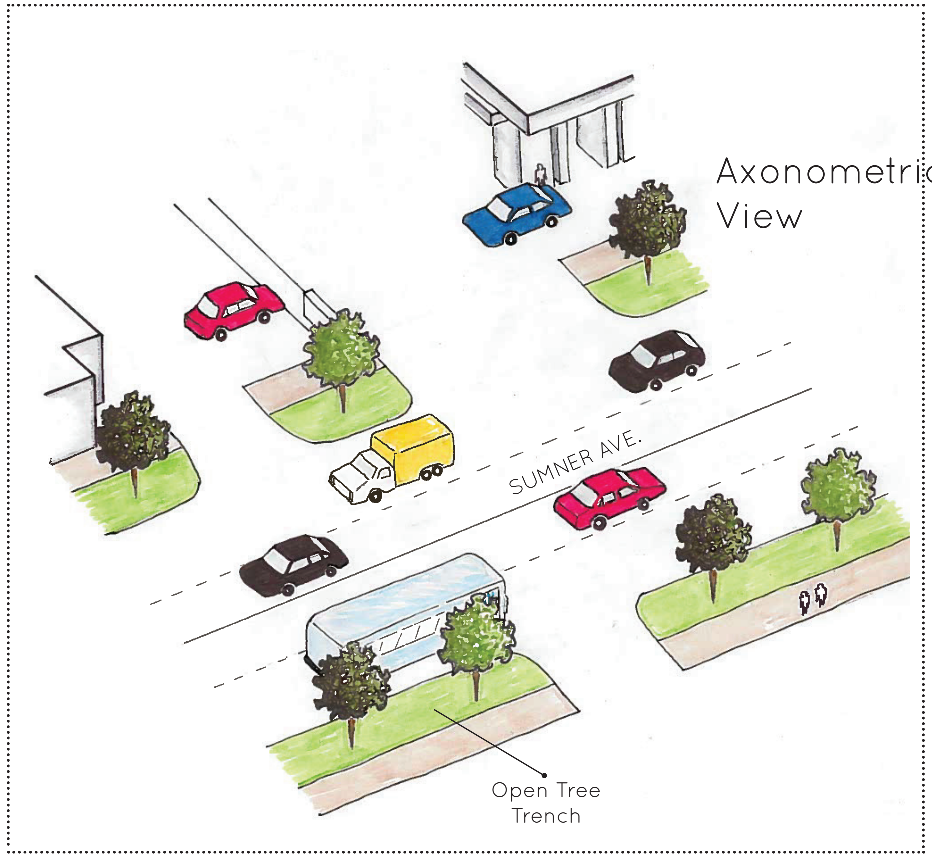
Plan View



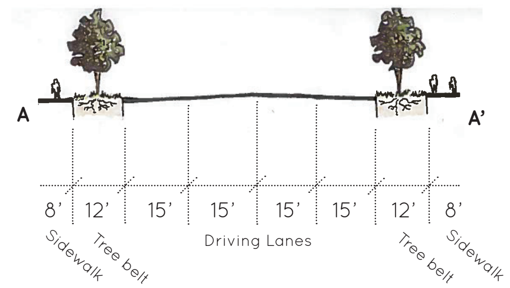
If possible the street profile of a boulevard should be shaped to direct runoff into a median bioswale which overflows during uncommonly large rain events into the combined sewer system. This median should be as wide as right-of-way allows in order to help calm traffic, reduce speeding and provide refuge for a pedestrians crossing the road.

In the tree belt along the edge of the roadway between the street and sidewalk, large trees should be left wherever possible in order to maintain their ecosystem services. Tree trenches are encouraged over tree box filters so that trees can grow large. However, tree box filters are a better option in areas with limited space and could replace younger existing trees.

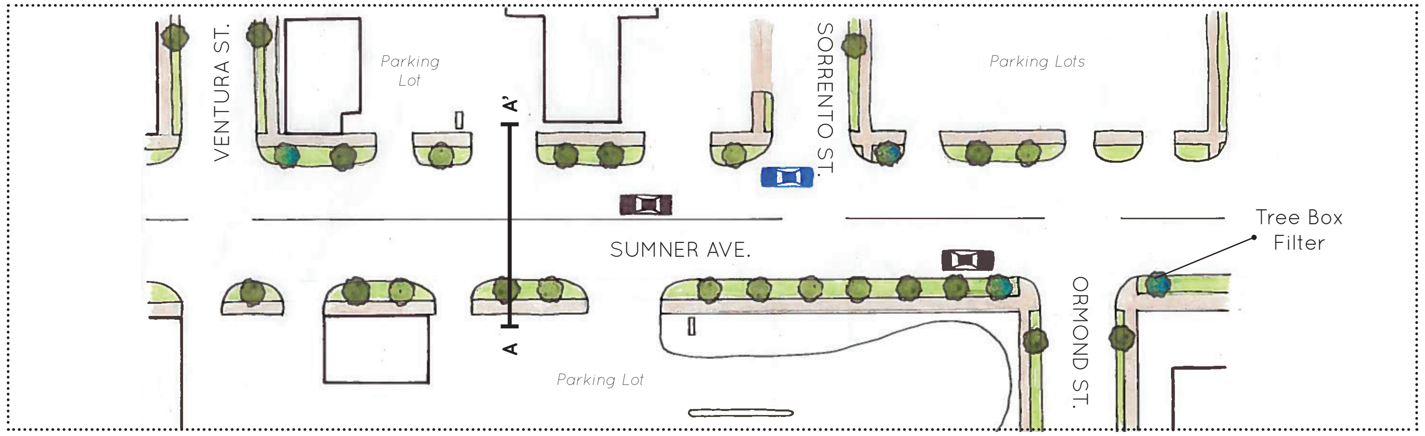
Bioswales connected to the combined sewer system are appropriate where there is ample space between root systems in existing tree belts.



Section View



Plan View



The northwest and southeast extent of the complete street proposal both contain a roundabout. The outer diameter of these structures must be paved and is suitable candidate for permeable asphalt. The interior of the roundabout could function as a rain garden which filters runoff from the road.

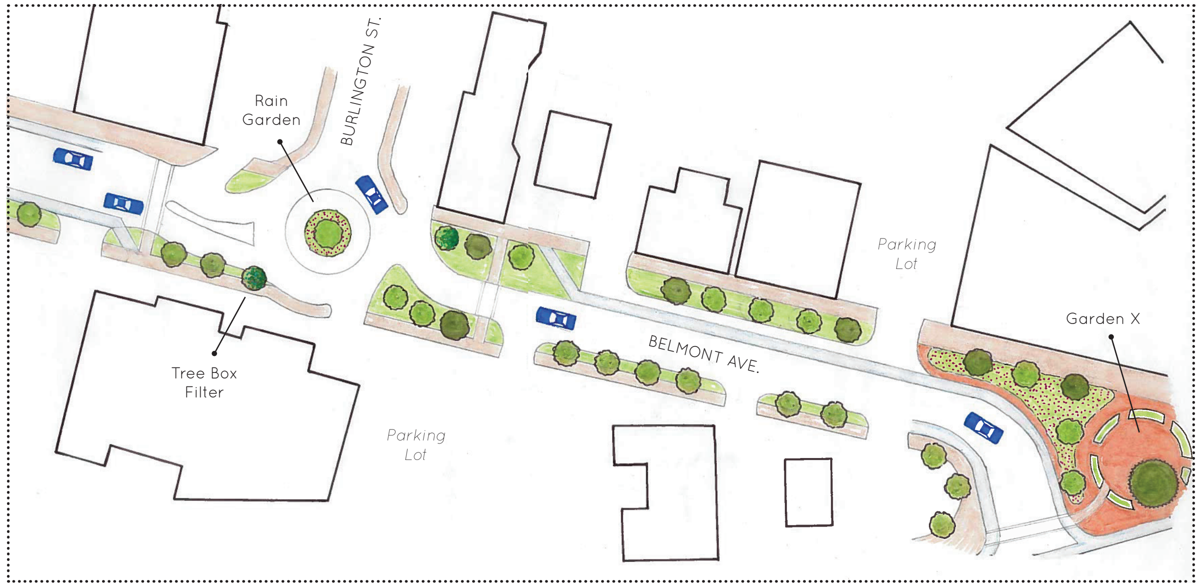
In order to maintain sight-lines, vegetation should be kept low, consisting of hardy perennial grasses and herbaceous plants which grow low and are tolerant of periodic drought, flooding and de-icing salts. Plant design should attempt to strike a balance between biodiversity and simplicity, to promote both ecological function and ease of maintenance.

Traffic Circle in Summit, NJ

Plan Views

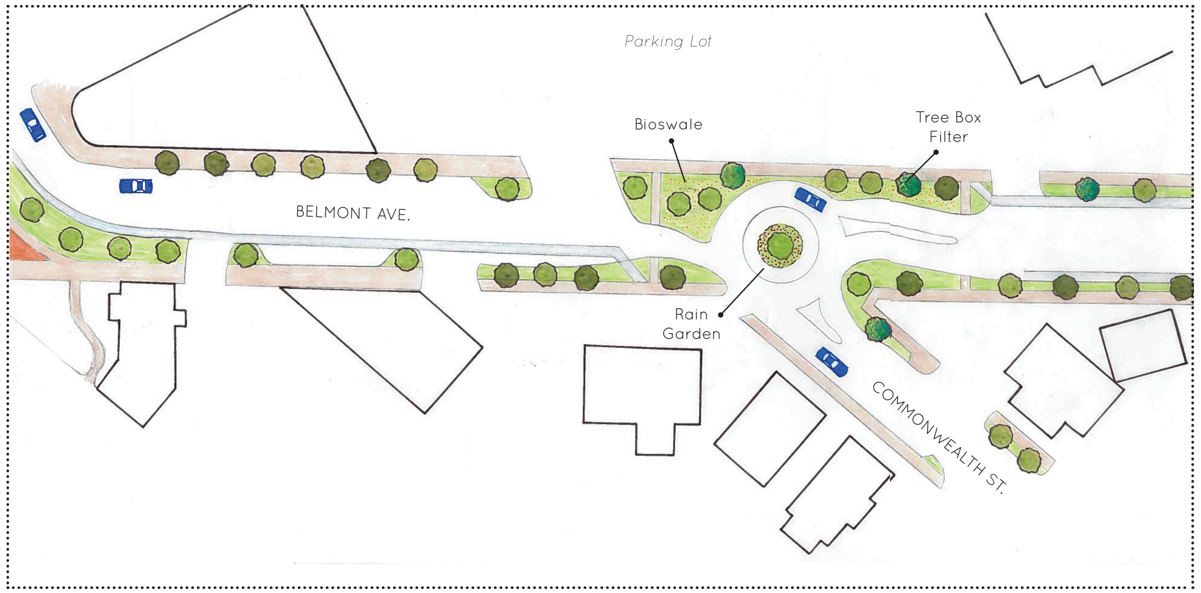
Belmont & Sumner Ave.

(Northwest)



Belmont & Sumner Ave.

(Southeast)



The Intersection: Garden X

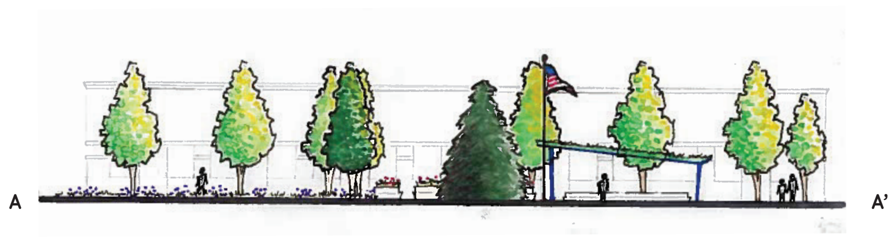
At the intersection, the northwest plaza serves as the "front stoop" for the numerous local retailers and businesses along Sumner and Dickinson. Designs here will be most effective if they help to fulfill the needs and augment the services provided by these businesses.

For example, designs could include informal seating for nearby restaurants, or those waiting to get their hair cut at the nearby barber shop.

Tree canopy should be maximized without blocking visibility to storefronts. Canopy cover helps mitigate the urban heat island effect while also providing pleasant shade and habitat for urban dwellers.

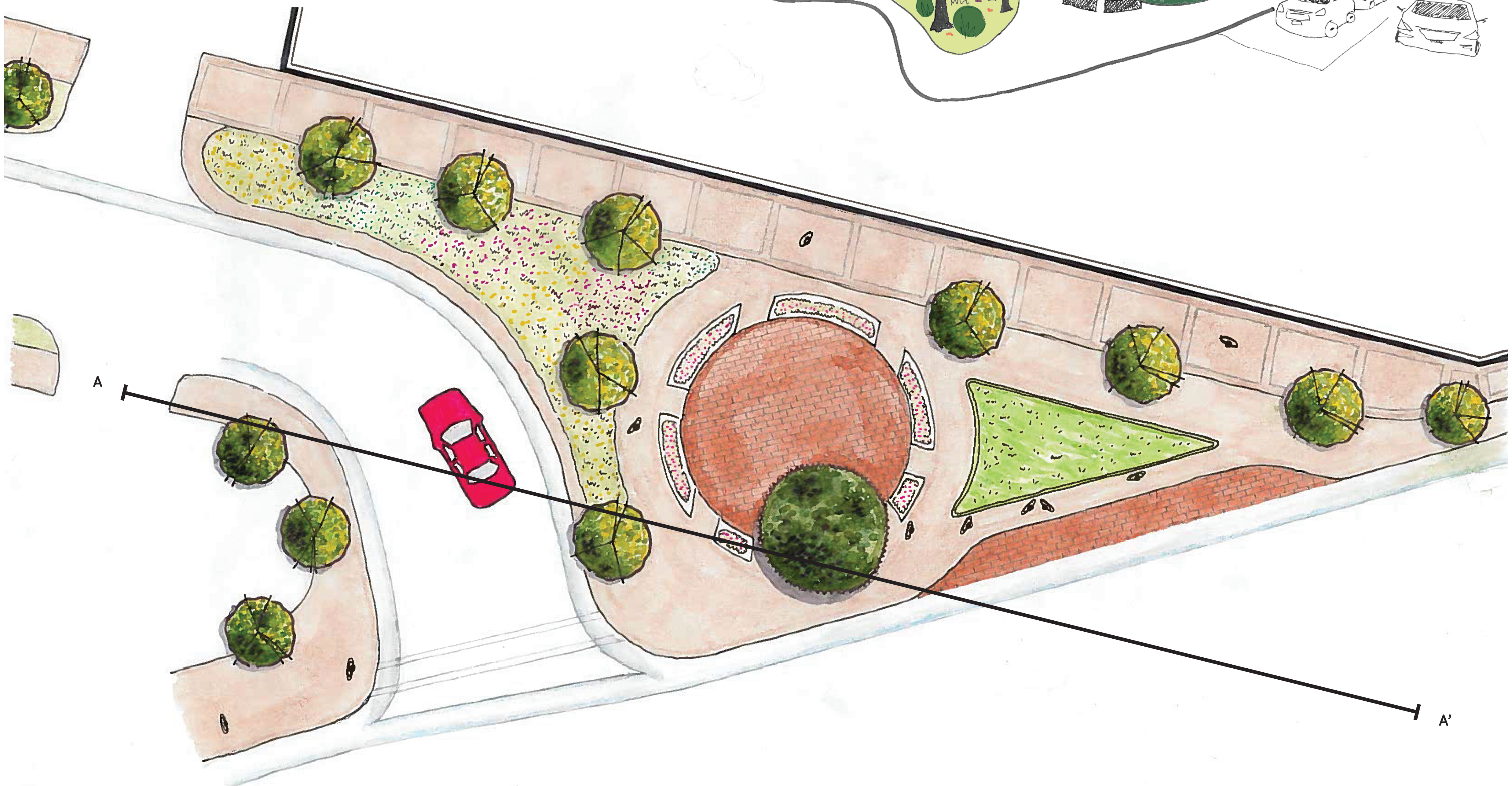
These designs include a large bioswale within the pedestrian plaza that captures diverted runoff from the road and/or commercial rooftops. A circular seating area can double as a flexible community space to host events such as caroling in the winter or a farmer's market in the summer. Perhaps such a market could extend north along Belmont on the sidewalk.

Section View



Rendering Sketch

Plan View

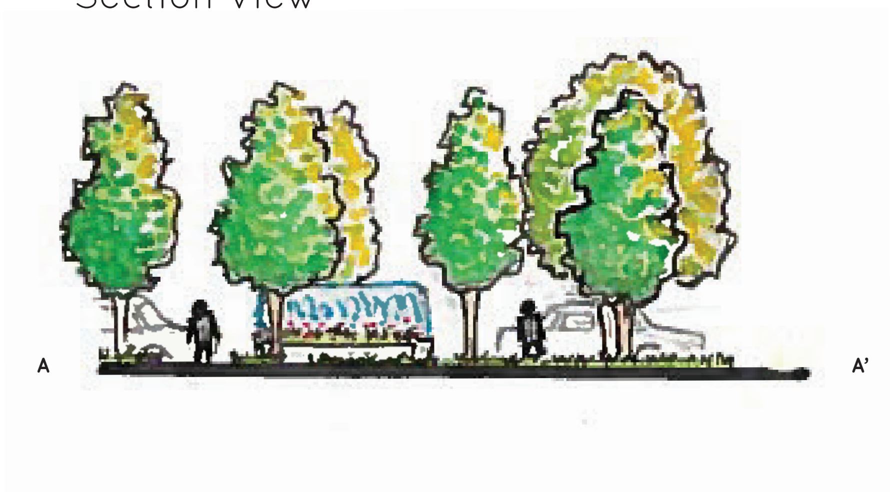


The southeast plaza sits like a peninsula projecting into the intersection and is currently abutting an automotive store and a Dunkin' Donuts.

Included in this design is a robust belt of trees and a fountain to mitigate the sight and sounds of automobiles rushing by. Ideally the fountain could use recycled rainwater, perhaps spilling into a foundation of permeable asphalt as a demonstration of its capacity.

Also included is a set of signs informing pedestrians about the history of the X and the intent behind the new green infrastructure.

Section View



Plan View

Rendering Sketch

RECOMMENDATIONS

Recommendations For the X and Beyond

Obtain more community feedback on the preliminary plaza designs proposed in this book.

The community that is most affected by changes at the X intersection are residents of the Forest Park Neighborhood and those who own shops abutting Belmont, Dickinson or Sumner. Further outreach to these populations would help ensure their engagement the final designs.

Meetings held after 5pm would maximize convenience for residents who work 9-5. Attendance at these meetings should represent the diversity of the community. Some residents might be unable to attend any meetings, such as those with family obligations or the owners of restaurants that are open late. Social media may be an effective way to survey a larger percentage of community members.

Another idea would be to formalize a Green Infrastructure Citizens Group or a Green Infrastructure Steering Committee as was done in New York City. These groups included highly engaged residents as well as "representatives from the development community, environmental and other nonprofit groups, academia, and design professionals, to help develop ideas and address concerns about the city's implementation of its green infrastructure initiatives" (Enhancing Communities 29). Such groups could help form a comprehensive plan, elaborated further below.

Community involvement in every step of design and implementation is necessary to cultivate a sense of ownership, increasing the likelihood that these systems are adopted and cared for by the community. Redesigning the X is a long term endeavor; keeping stakeholders engaged and enthusiastic may be a challenging barrier to long term success.

Set incremental and measurable health goals to:

Improve Water Quality — An ideal opportunity for city-wide citizen science, water quality samples taken from the outfall locations along the length of the Connecticut River or in water bodies in Forest Park would indicate whether water quality was improving or deteriorating over time. This would be an invaluable place-based learning field trip for the many local elementary and middle school students.

Increase Biodiversity — How many native birds, bees and butterflies live in the X neighborhood? How many species of trees or native pollinator food sources are available nearby? Such questions engage local students and residents alike and encourage nature connection. These first two goals are also an opportunity to partner with the biology department of one of the five local universities.

Reduce Impermeable Surface — It is critical that the X neighborhood and the city as a whole reduce impermeable surface to reduce the likelihood of CSO events. The city could set annual targets for the conversions of impermeable to permeable pavement and removing hard surfaces altogether. For example, if there are 8,000 acres of impermeable surface in the city, setting annual reduction goals of 1% a year would mean converting 80 acres of permeable to impermeable surfaces – an ambitious goal. Approximate calculations could serve as inspiring benchmarks, indicating that the city is getting closer to eliminating the possibility of CSO events fulfilling the EPA mandate.

Set Tree Canopy Goals — Increased tree canopy means more green space in the city and is closely correlated with watershed health. Such goals have been set in communities like Baltimore, Maryland which had an urban tree cover of 20% in 2006 and has committed to a 46.3% cover to be attained by 2030–2036. (UTC Guide 47) Forest cover of 45% is associated with healthier local streams. Setting similar goals within Springfield is a valuable means of acquiring further state funding.

Set Other Longterm Health Goals – Document asthma rates, obesity, ecological illiteracy, and mental health issues. Increasing the ecological health of a city has a direct correlation to the health and wellbeing of human residents in that ecosystem. These and other measurements help to quantify the livability of the city.

Encourage stewardship within the community.

Educate and Inspire — The installation of systems from the toolbox could be used as demonstration sites that help to inform and inspire the residents what is possible on their own street and in their own yard. This approach has found success in places such as Milwaukee, WI where public rain garden demonstration sites encouraged residents in the nearby area to install similar systems on their own properties. (Sustainable Communities 29) There are also several schools in the X neighborhood (Beal Elementary, Washington Elementary, Forest Park Middle, Kensington Avenue Elementary, Sumner Avenue Elementary, and White Street Elementary) which provide significant opportunity to engage the youngest residents and future stewards of the community. Educational efforts could dovetail with measurable health goals such as improving water quality and biodiversity mentioned on the opposite page. Participation in such programs leads to awareness of local issues and neighborhood stewardship.

Incentivize Green Tools — Many of these systems, such as rain barrels and rain gardens, are small scale and can be implemented at home. Individually, their impact is small, but collectively their impact is great. Programs to incentivize rain barrels through rebates have encouraged implementation in some communities. Portland, Oregon, for example, initiated a downspout disconnection program, which now diverts 1 billion gallons from the combined sewer system annually (Rooftops to Rivers 15). Since parking lots make up a large percentage of impervious surface at the X, incentivizing the retrofitting of private parking lots in the intersection would provide significant reduction in impervious surfaces.

Establishing a stormwater utility can generate revenue to incentivize the establishment of green systems. This technique has been applied in over 400 communities across the country, although only a few communities in Massachusetts currently participate in this program, including Chicopee, a pilot program for the Commonwealth. For more information see the "Assessment of Stormwater Financing Mechanisms in New England" produced by the Charles River Watershed Association.

Develop Comprehensive Green Infrastructure Guidebook.

Such a guidebook outlines green infrastructure priorities within the city. Valuable models include "Green City, Clean Waters," an expansive plan by the City of Philadelphia that envisions city-scale implementation of green stormwater infrastructure. (CWGC, 3)

Include Operations and Maintenance Plan — Failure to properly maintain green infrastructure can severely reduce the effectiveness of these systems, negating the ecosystem benefits and life-cycle cost savings. Because these systems are new to many residents and city workers alike, the success of early systems is essential to bolster confidence in the viability of these projects. Problems can be avoided by designing and implementing a basic Operations and Maintenance Plan, which consists of "identification of the party(ies) responsible for maintenance schedules, inspection requirements, frequency of inspections, easements or covenants for maintenance, and identification of a funding sources" (EPA Maintenance 10). Also included would be a description of "basic maintenance activities such as weeding, mulching, trimming of shrubs and trees, replanting, sediment and debris removal, and inlet/outlet cleaning" (EPA Maintenance 10).

Prioritize Job Creation — The installation and maintenance of these new systems is a valuable opportunity to provide a meaningful livelihood to residents. Seasonal maintenance such as weeding and mulching of neighborhood installations are suitable for part-time work, such as seasonal summer work for high school students or individuals transitioning into permanent work.

Create Partnerships — The development and implementation of such a plan would help create partnerships within the city and beyond, especially with local universities. For example, in 2010, the City of Freeport, Illinois partnered with the University of Wisconsin-Madison's Department of Urban and Regional Planning to provide hands-on, practical training in planning. The aim was to "use green infrastructure planning to reduce flooding, make neighborhoods more attractive, revitalize downtown, create jobs, and clean up contaminated properties so they could be developed into assets for the community" (Sustainable Communities 29).

CONCLUSION

The discharge of raw sewage into the Connecticut River during heavy rain is a severe problem. Fortunately, Springfield is not alone in facing these problems. As numerous cities across the country have developed innovative systems that use living plants to decontaminate urban runoff. When designed thoughtfully, these systems effectively slow down stormwater and allow it to infiltrate into the soil, reducing the likelihood of a Combined Sewer Overflow event.

Since they use trees, these systems have numerous other benefits such as decreased crime, cleaner air, cooler hot weather temperatures, climate change mitigation through carbon sequestration and reduced electricity demands. In a dense urban area, these systems also provide a dose of nature to residents who would otherwise have to travel outside of the city to contact nature.

A city that fully adopts and is enthusiastic about ecological streets could transform over time, street by street over the course of decades, into a landscape that finds a balance between the performance needs of the human residents and the needs of local waterways and ecosystems. For the first time, a city's street infrastructure can make people happier, healthier, safer and more engaged with their environment.

Springfield, a city of firsts, forests and innovation, can be a leader in green infrastructure in western Massachusetts and in New England.

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Water Service Areas Map. Springfield Water and Sewer Commission. January 7 2016 3:19pm. *<http://www.waterandsewer.org/pdfs/Water_Service_Map.pdf>*

Wastewater Treatment Map. Springfield Water and Sewer Commission. January 7 2016 3:19pm. *<http://www.waterandsewer.org/pdfs/Wastewater_Service_MAp.pdf>*

Image Credits

All hand-drawn illustrations and design graphics were created by Eric Depalo and Breyonne Golding.

Photos are in order of occurrence within the report:

Main Street in Springfield, 1908. Wikipedia, Web. 8:07am, 20 March 2016. *<https://en.wikipedia.org/wiki/Springfield,_Massachusetts#Water_and_sewer_system>* Pg. 2

Wastewater Discharge. Wikipedia, Web. 12:26am, 23 February, 2016. *<https://en.wikipedia.org/wiki/Effluent>* Pg. 4

Massachusetts Main Street in The City of Progress, circa 1910. Wikipedia, Web. 9:21am, 20 March 2016. *<https://en.wikipedia.org/wiki/History_of_Springfield>* Pg. 7

Streetside Swale High Point Neighborhood in Seattle, Washington. December 2008. Environmental Protection Agency. 1:16am, 23 February, 2016. *<Wikimedia. Web. commons.wikimedia.org/wiki/File:Streetside_swale_Seattle.jpg>* Pg. 8

Cop in a Box. Facebook, Web. 10:16am, 23 February, 2016. *<https://www.facebook.com/SpringfieldMassachusettsMyHometownAndLovinIt/photos/pb.274369549295195.-2207520000.1458782986>* Pg. 9

X Newspaper Articles. Facebook, Web. 10:27am, 23 February, 2016. *<https://www.facebook.com/SpringfieldMassachusettsMyHometownAndLovinIt/photos/pb.274369549295195.-2207520000.1458782986>* Pg. 9

Bioretention in West Seattle. Wikipedia, Web. 1:01pm, 24 March 2016. *<https://en.wikipedia.org/wiki/West_Seattle,_Seattle>* Pg. 12

X Intersection in Springfield, MA Aerial. City of Springfield, MA Department of Public Works. 6:15pm, 19 February 2016. Pg. 15

Storm Drain. Wikimedia, Web. 12:26am, 23 February, 2016. *<https://upload.wikimedia.org/wikipedia/commons/0/09/Storm_Drain.JPG>* Pg. 27

Cook, Louis. Washington Ave Tree Trench. May 2013. Philadelphia Water Department. Wikimedia, Web. 8:00am, 20 March 2016.*<https://www.flickr.com/photos/philadelphiawater/9085775937>* Pg. 29

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Green roof of the Mountain Equipment Co-op store in Toronto, Canada. Wikimedia, Web. 3:36pm, 21 March 2016. *<https://en.wikipedia.org/wiki/Green_roof>* Pg. 35

Novak, Tia. ReGreening the X Public Meeting. Several Photos of a Private Collection. February 2016. Pg. 39

Amur Maackia. Portsmouth, New Hampshire, United State. July 2013. Flicker, Web. 8:38am, 22 March 2016. *<https://www.flickr.com/photos/psnh/13983645136>* Pg. 35

Cornus sericea ssp sericea. US Forest Service. October 2010. Flicker, Web. 8:45am, 22 March 2016. *<https://www.flickr.com/photos/superiornationalforest/5098096262>* Pg. 35

Rasbak. Ruwe smele plant (Deschampsia cespitosa). June 2005. Wikimedia, Web. 8:49am, 22 March 2016. *< https://commons.wikimedia.org/wiki/File:Ruwe_smele_plant_Deschampsia_cespitosa.jpg>* Pg. 35

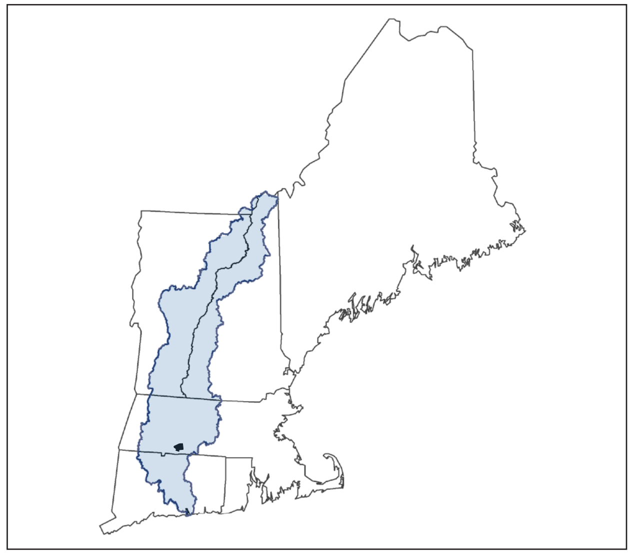
Langlois, Danielle. Blue flag flower (Iris versicolor). July 200.5 Forillon National Park of Canada, Quebec, Canada. Wikimedia, Web. 8:52am, 22 March 2016. *< https://commons.wikimedia.org/wiki/File:Iris_versicolor_2.jpg>.* Pg. 35

Sulcer, Tom. Traffic island near the train station in Summit, New Jersey. October 2011. Wikimedia, Web. 8:04am, 23 March 2016. *<https://commons.wikimedia.org/wiki/File:Summit_NJ_Traffic_Circle_Tree_Train_Station.jpg>* Pg. 53

Map Data Sources

REGIONAL WATERSHED

Inventory & Analysis Section, Page 16
Map of the regional watershed in relationship to the City of Springfield, MA.



Data Sources

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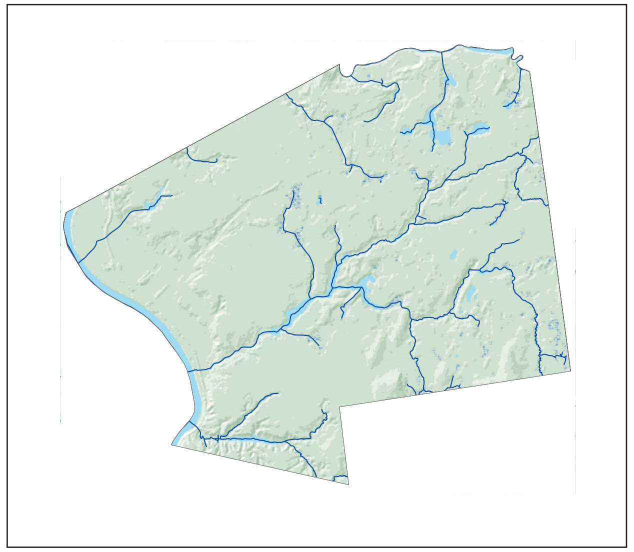
- State Boundaries Outline
- Major Watershed
- Towns Boundaries

Data Created by E. DePalo & B. Golding
- Watershed Color Overlay. Created February 2016.

CITYWIDE: WATERWAYS

Inventory & Analysis Section, Page 16
Map of the City of Springfield, MA local waterways.



Data Sources

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- Hydrography (1 : 25,000)
- Shaded Relief (1 : 5,000)

Data Created by E. DePalo & B. Golding
- Springfield Boundary. Created February 2016.

CITYWIDE: IMPERMEABLE SURFACES

Inventory & Analysis Section, Page 17
Map of the city's roadways, parking lots, sidewalks, roof and other impermeable surfaces.

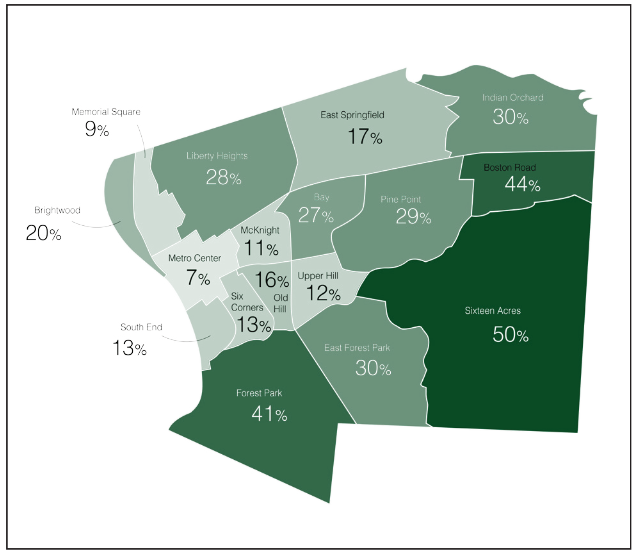
Data Sources

Massachusetts Office of Geographic Information (MassGIS)
- Impervious Surfaces

Data Created by E. DePalo & B. Golding
- Springfield Boundary. Created February 2016.

CITYWIDE: TREE CANOPY COVER

Inventory & Analysis Section, Page 18
Map of the city's tree canopy cover percentages by neighborhood.



Data Sources

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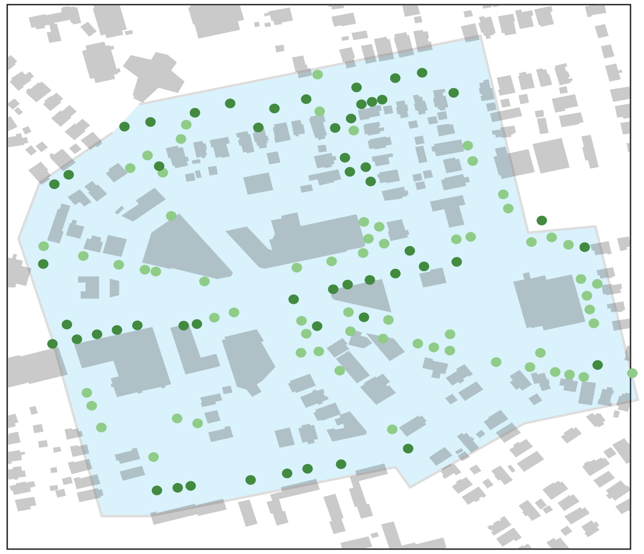
Data Created by E. DePalo & B. Golding
- Springfield Neighborhood Boundaries. Created February 2016.

SITE: TREE INVENTORY

Inventory & Analysis Section, Page 19
Map of the project site's existing tree placement.



Data Sources

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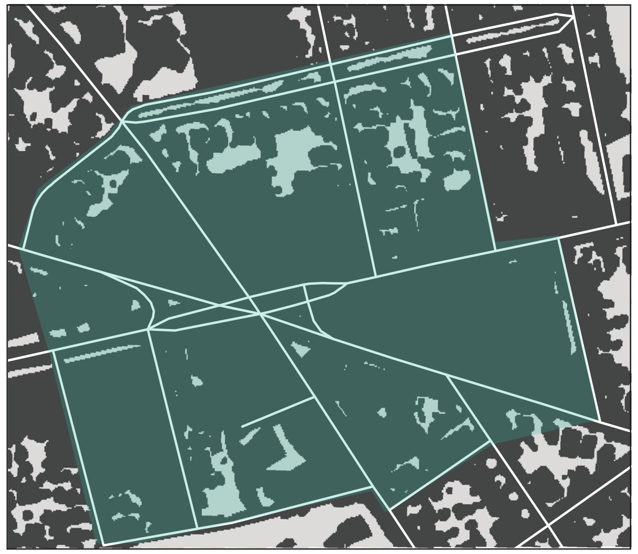
Data Created by E. DePalo & B. Golding
- Project Area Boundary. Created February 2016.
- Tree Inventory Locations. Created March 2016.

SITE: IMPERMEABLE SURFACES

Inventory & Analysis Section, Page 20
Map of the project site's roadways, parking lots, sidewalks, roof and other impermeable surfaces.



Data Sources

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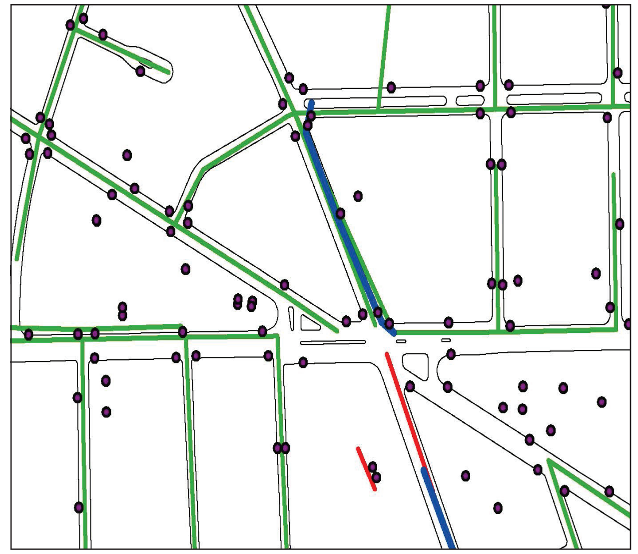
- Massachusetts Department of Transportation Roads (MassDOT)

Data Created by E. DePalo & B. Golding
- Project Area Boundary. Created February 2016.

Map Data Sources

SITE: DRAINAGE

Inventory & Analysis Section, Page 21
Map of the project site's sewer system and catch basins.



Data Sources

City of Springfield Department of Public Works (Springfield GIS)
. Sewer System & Catch Basins PDF

SITE: LAND USE

Inventory & Analysis Section, Page 22
Map of the project site's commercial, residential and institutional land uses.

Data Sources

Massachusetts Office of Geographic Information (MassGIS)
. Structures (Poly)
. Land Use 2005
. Massachusetts Department of Transportation Roads (MassDOT)

SITE: HUMAN CIRCULATION

Inventory & Analysis Section, Page 23
Map of the project site's bus stops, vehicle and pedestrian circulation.

Data Sources

Massachusetts Office of Geographic Information (MassGIS)
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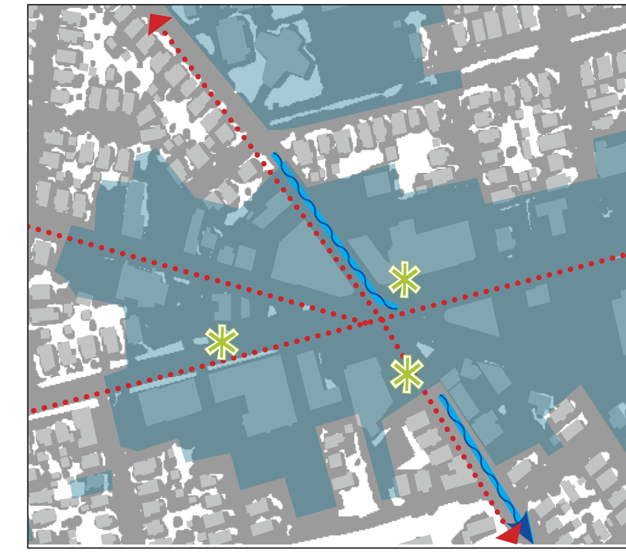
Data Created by E. DePalo & B. Golding
. High Traffic Areas. Created March 2016.
. Vehicle Routes. Created March 2016.
. Pedestrian Patterns. Created March 2016.
. Bus Stop Locations. Created March 2016.

SUMMARY ANALYSIS

Inventory & Analysis Section, Pages 24-25
Map of the main analysis features within the project site.



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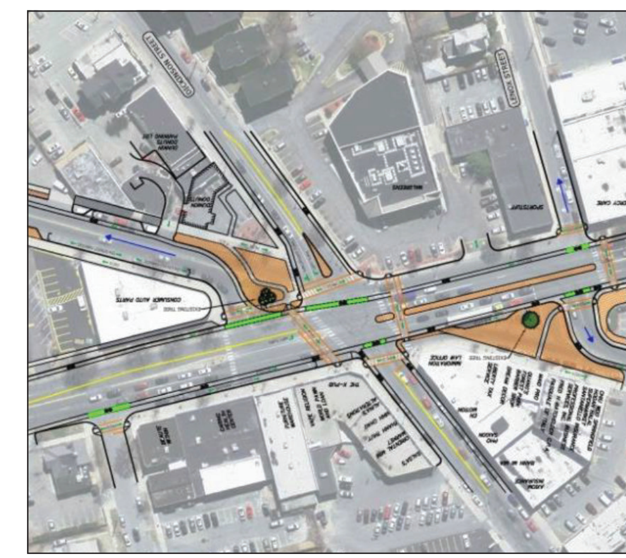
. Bus Stop Locations. Created March 2016.

X INTERSECTION PROPOSAL

The "X" Section, Page 38
Map of the X intersection reconfigration proposal.



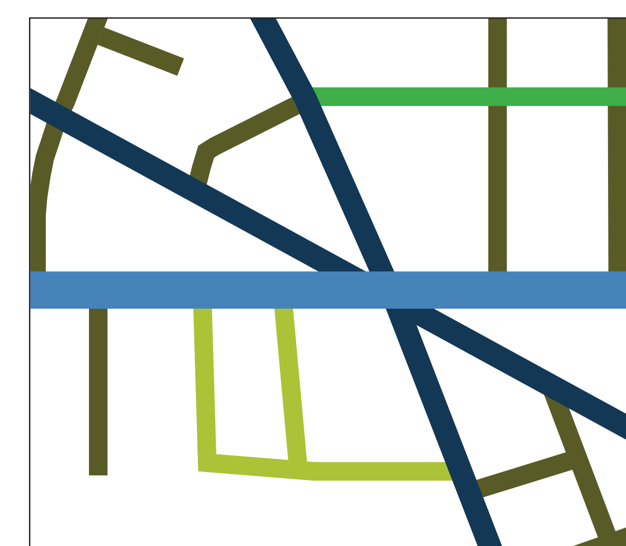
Data Sources

Tighe & Bond
. Sumner, Belmont and Dickinson Street Reconfigration Proposal PDF

Google Earth
. Aerial Photo

STREET CATEGORIES

The "X" Section, Page 40
Map of the street categories in the project site.



Data Sources

Data Created by E. DePalo & B. Golding
. Color Coded Streets. Created February 2016.

Map Data Sources

EXISTING TREE LOCATIONS

The "X" Section, Page 42-43
Map of the project site's existing tree placement.

Data Sources

Google Earth
. Aerial Photo

Data Created by E. DePalo & B. Golding
. Tree Inventory Locations. Created March 2016.

TREE BOX FILTERS PLACEMENT

The "X" Section, Page 44-45
Map of the ideal tree box filters locations within project site.

Data Sources

City of Springfield Department of Public Works (Springfield GIS)
. Catch Basins PDF

Google Earth
. Aerial Photo

Data Created by E. DePalo & B. Golding
. Tree Box Filters Locations. Created March 2016.

OTHER TOOLBOX FEATURES PLACEMENT

The "X" Section, Page 46-47
Map of the ideal locations for other toolbox features within project site.

Data Sources

Google Earth
. Aerial Photo

Data Created by E. DePalo & B. Golding
. Other Toolbox Features Locations.
Created March 2016.